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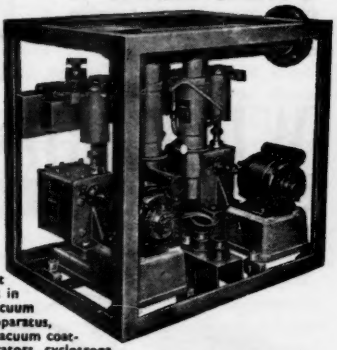

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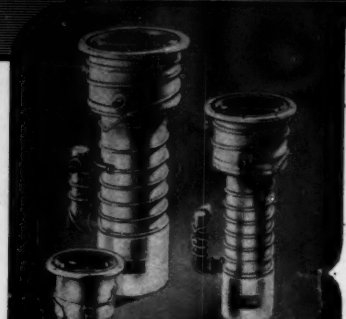

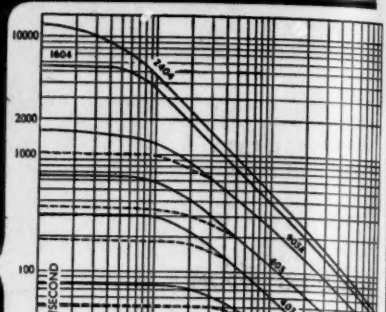

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NATURE

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TECHNICAL AND TECHNOLOGICAL EDUCATION IN GREAT BRITAIN

A DISAPPOINTING feature of the fourth report of the Advisory Council on Scientific Policy, the general features of which were discussed in *Nature* of September 22, is its failure to give a clear lead on the question of higher technological education in Great Britain. The contents of the subsequent White Paper on Higher Technological Education are equally disappointing (see *Nature*, September 29, p. 543). Presented to Parliament by the Chancellor of the Exchequer, the Lord President of the Council, the Minister of Education and the Secretary of State for Scotland, it is marked above all by anxiety to avoid giving offence. With an ingenuity which compels the admiration even of those who deplore its shortcomings, it evades all the important issues and contributes nothing to the necessary long-term policy. For the present there is prescribed the mixture as before: the universities will strengthen their existing departments of technology, and one or two may be enabled to expend much more considerably. The civic pride of anything up to sixty-six local authorities will be satisfied by additional financial assistance to their technical colleges, and expansion will begin along lines shortly to be announced.

In a measure, these proposals meet the imperative need for early decision so that the universities and the technical colleges can make their appropriate plans. How far this expansion will meet the real national needs, and above all that to which the Percy Committee directed attention more than six years ago, cannot well be judged until the detailed proposals for making improved financial assistance available for selected technical colleges and courses are made known and until the University Grants Committee announces the results of its examination of the proposals for university expansion, presumably in connexion with its plans for the next quinquennium. Meanwhile, however, a College of Technologists is to be established with responsibilities limited to granting awards and the approval of courses, thus shearing of some of its dangers the ill-considered recommendation of the National Advisory Council on Education for Industry and Commerce.

It is not suggested that the expansion of the university departments of technology and of the technical colleges will not give some useful increase in the number of highly trained technologists as distinct from technicians. That distinction is not made clear in the report, in spite of the recognition that industry needs recruits of a wide range of types, outlook and experience. What is clear from the statement is that university expansion in this field and the expansion of the technical colleges shall continue to proceed independently. The need for one body capable of taking an impartial and a national view is ignored.

This is the first major defect in the proposed policy, and until it is remedied it is idle to talk of using available resources so as to give the best

results in the short as well as in the long run, or to make the most appropriate use of existing institutions. No comprehensive and satisfactory national system of higher technological education can be evolved in its absence. Six years ago, the Percy Committee recorded the general view that the position of Great Britain as a leading industrial nation was being endangered by a failure to secure the fullest possible application of science to industry, and that this failure was partly due to deficiencies in education, especially to a shortage of scientific workers and technologists who can also administer and organize, and can apply the results of research to development.

That is the background to all subsequent discussions on higher technological education in Britain, and in his recent book, "The Neglect of Science", Prof. F. E. Simon states that a visit to the United States strengthened his conviction that the most important thing needed to make our industry competitive is the reform of technological education in Britain. Such reform will not be secured by patching the existing system; and, disregarding for the moment Prof. Simon's own preference for at least two new technological institutions of university rank, the first step to a coherent national policy of higher technological education is to make its supervision the responsibility of some one body, whether it is carried out in university institutions or in appropriate technical colleges. If for valid reasons the establishment of a special Technological Grants Committee—a suggestion to which the National Advisory Council on Education for Industry and Commerce gave inadequate attention—is impracticable, the duty should be entrusted to the University Grants Committee with appropriately enlarged terms of reference.

The first essential is a body that can take independent and long views, with authority and standing sufficient to resist sectional pressure. The importance of this condition is at once apparent when we consider the question of the selection, from among the sixty-six existing colleges said to be providing higher technological education in Great Britain, of those which are to receive increased financial assistance. There is no indication as to who is to make the selection or the grounds on which it is to be based. From the national point of view, it is unnecessary and undesirable to upgrade to university status more than about six such institutions. The National Advisory Council in its report suggested that the actual selection should be made after consultation with the regional academic boards, which were established by the Ministry of Education to give advice in the field of technology. There are, however, ten such boards, and it would be optimistic to expect that such boards will take a national point of view and not incline to favour colleges in their own area. Ruthless decisions in favour of a few institutions, in fact, can scarcely be expected of such bodies; but without such ruthlessness there is grave danger that the limited amount of money available will be distributed too widely to make any real improvement anywhere.

The second essential condition for the development of higher technological education in the technical colleges is a matter not of finance but of status. The White Paper fails as completely as the report of the National Advisory Council on Education for Industry and Commerce to show any appreciation of the importance of the question of independent governing bodies and full academic freedom for the selected colleges. The issue is evaded or ignored; but this question of status and of academic freedom is of vital importance.

Unless the selected colleges are able to attract teachers of high standing and ability there is little hope of any real improvement in their status. More generous financial support and the full adoption of the new Burnham awards will be insufficient while the control by local authority and the Ministry of Education remains. Incidentally, it should be remembered that, even if that obstacle were removed, there are insufficient teachers of high calibre available to conduct the requisite courses in more than a fraction of the present sixty-six colleges. Such teachers are unlikely to be obtained unless they can be offered conditions of service fully comparable with those at the universities by removal of the subjection of the colleges to local authority and Ministry.

This question of staff is critical. Unless the difficulty is faced and overcome, the selected colleges will never acquire the status which will enable them to attract students of high quality, and no awards made by the College of Technologists will be comparable with either a university degree or the qualifications of the professional institutions. The proposal for a College of Technologists contributes nothing new and bypasses all the real difficulties. It cannot even be described as putting the cart before the horse, for if the real problems of upgrading a few selected colleges to university level are handled with courage and vision, a new award would be superfluous, just as it will be valueless if those problems are not solved.

Half-hearted solutions which merely avoid difficulties will get us nowhere, and so far as can be judged at present there is to be no real change in policy. Some return will be secured from the expansion in the university departments of technology now being made in the universities, but as regards the technical colleges less confidence can be felt. There is real danger that the available resources will be distributed too widely to make any effective contribution anywhere to the provision of technologists of the calibre required, and the White Paper gives no indication that the situation will be handled with vision and imagination.

The White Paper does not, it is true, exclude indefinitely the possibility of a technological university. The proposal is rejected for the present on account of the capital outlay required, and because such a project for an entirely new centre would involve at least five or six years of planning and building, so diverting large resources required elsewhere and yielding no return in the form of graduates for at least ten years. Even the expansion of an existing institution would involve heavy capital cost and building commitments, and here again no rapid return could be expected.

These, and especially the last, are the wrong reasons. There are no firm grounds for assuming

that in any foreseeable time more resources will favour experiment. The situation is more likely to deteriorate than to improve, as is indicated by the remarks made on October 1 by the retiring vice-chancellor of the University of Cambridge on the financial anxieties of the University in view of rising costs. The most promising methods of reform are usually expensive; but caution and a predilection for ways that have been found wanting are no policy for a nation in difficulties.

It may have been right to reject the idea of founding an entirely new technological university, though the White Paper would have been more convincing had it faced frankly the arguments in its favour, and particularly the danger that expansion of technology in the universities themselves may distort their balance of teaching and research. This problem has already been discussed by Prof. A. R. Ubbelohde and others. Technological research is liable to involve expensive and specialized equipment to a greater extent than academic research, except perhaps in some fields; and we cannot ignore the possible effect on the university departments if expansion takes place in the main at the universities. Equally, whatever expansion is planned at selected colleges of technology must provide for research as well as for teaching, and the same problem, possibly in even greater measure, will arise there also.

We are forced, therefore, to conclude that not only must the expansion of higher technological education in Great Britain be planned by one body, but also that that body must be competent to take account of the work of the research institutes and research associations and to advise on the best location of specialized equipment from the national point of view, having regard to teaching as well as research. Unless this is done, it is idle to talk of the wisest and most effective use of limited resources. It is right that there should be a reasonably wide range in the type of provision to be made for higher technological education: the universities, the colleges of technology, possibly also the research associations and other research institutions have their contribution to make, and, if only on the ground of variety, it is to be regretted that further experiment by establishing a higher technological institution is not to be undertaken.

There is an additional reason, not mentioned in the White Paper, for regretting that decision. In his recent Redwood Lecture before the Institute of Petroleum, on "The Training of a Technologist", Prof. F. H. Garner, professor of chemical engineering in the University of Birmingham, made much the same point as Lord Hankey emphasized in his Centenary Lecture on higher technical and scientific man-power a little more than a month earlier. Both stressed the importance of the technologist possessing certain qualities of character and leadership, and the desirability of providing in his training the conditions which encourage the development of such qualities. It is worth noting that Dr. P. Dunsheath, commenting on his recent visit to the United States as a member of the team sent by the Anglo-American Council on Productivity to study relations between the universities and industry, remarked that industry there also is looking for like qualities, and the universities are seeking to develop them.

There are some pertinent observations on this topic, as well as some useful suggestions, in the Walker Trust Lecture, "The Universities and Cultural Leadership", which Sir Walter Moberly delivered before the University of St. Andrews last February, and in which he firmly maintained that education for social responsibility is still a legitimate and necessary task for universities. Sir Walter denounced as heresy the doctrine that the only business of the universities is to turn out specialists, and the doctrine is no less pernicious when it is applied to the colleges of technology. But what is most significant in the present connexion is not that Sir Walter expressed a view which has been strongly endorsed from the industrial side in recent discussions on higher technological education, but rather his reminder that the universities develop such qualities not merely by requiring their students to submit to the basic intellectual disciplines of mathematics and classics, but chiefly by bringing together teachers and students who represent a wide circle of interests and providing them with a stimulating community life.

There, in short, is a compelling reason for experimenting with a technological university. The stimulus which might be derived from bringing together leading minds in many different technologies in one university centre has been overlooked. This was plainly as much in Prof. Garner's mind as in Sir Walter Moberly's, and such contacts are one means of encouraging the awareness and study of human relationships which Prof. Garner rightly stressed as an essential element in the training of engineers, or of other technologists, who throughout their careers will be concerned with human as well as with technical problems. Moreover, such a centre is in a far better position to dispel the notion which still persists that a career in technology is in some way inferior in status to that in some other professions, particularly if in organizing its courses of study care is taken to avoid keeping them in water-tight compartments.

The segregation of various departments of knowledge in existing university departments is one cogent reason for desiring to experiment with a new institution, without at the same time ceasing to encourage the expansion of some existing university departments of technology or of selected colleges of technology. Part of the value of a new technological institute may well lie, in fact, in its influence on the colleges of technology and the university departments. The graduate schools of technology, for which Prof. Garner pleaded in conclusion, could find their place either in the universities or in the expanded and upgraded colleges of technology, but would probably prove most fruitful in a new institution of the type of the Massachusetts Institute of Technology. Even in present circumstances, with the full support and co-operation of industry, such an experiment should not be beyond our resources; and the indirect results, as well as the direct return in graduates in

technology, should be considered before rejecting such a proposal.

Prof. Garner in his Redwood Lecture recognizes frankly that the techniques of industry are not appropriately taught in a university, nor indeed in a college of technology: they must be acquired in industry itself. In the university or the college of technology, the student should be taught why different techniques are used and the principles on which they are based. If the teaching is at the same time directed to encourage the development of the personalities of individual students, those administrative defects to which, like Lord Hankey, Dr. R. P. Russell, Sir Handley Page and others, Prof. Garner directed attention, are less likely to be in evidence.

Those defects are due primarily to the lack of a balanced outlook on the part of a technologist or scientific worker who is called upon to assume administrative responsibilities. In his book "The Impact of Education on Society", Mr. W. O. Lester Smith suggested three years ago that the right answer to the Barlow Report might be found in a nobler conception of the technical college rather than in a multiplication and expansion of universities. Prof. Garner's Redwood Lecture is only one indication of the extent to which a nobler conception of technological education as well as of the technical colleges marks current contributions to the discussion on higher technological education in Britain. That conception is conspicuously absent from the White Paper. Without it, without imagination, enterprise and the readiness to experiment, neither the formulation of policy nor its execution in practice is likely to meet what is now one of the most urgent needs if the industrial future of Great Britain is to be made secure.

THE TEACHING OF PHYSICAL CHEMISTRY

The Structure of Physical Chemistry

By Sir Cyril Hinshelwood. Pp. viii+476. (Oxford: Clarendon Press; London: Oxford University Press, 1951.) 35*s*. net.

THE presentation of physical chemistry to students presents difficulties to the teacher. Sometimes the subject is broken down into separate chapters and dealt with as a series of specialisms; sometimes various aspects and ideas are taken up as tools to be used in other fields of chemistry; and sometimes the subject is dealt with in a broad sweep of impressionism. All these methods have their own advantages and disadvantages.

It is right that the student should study in detail the important specialized aspects of his subject, so that he may be able to use the tools of physical chemistry sharpened, and with the skill of a good craftsman. But such studies alone tend to obscure the nexus of ideas which connect these specialisms and to lose the threads which run through the subject as a whole.

It is right that as early as possible the student should see the subject as a whole, and should appreciate the position of physical chemistry between physics, concerned with the general principles governing matter, and chemistry, concerned with the individual behaviour of substances and their variety. The young student should, like the children of France, 'speak French well': it is exciting and inspiring for him to use his new-learnt language in other branches of chemistry and to discuss organic reactivity and the manifoldness of inorganic phenomena in terms of the pattern-forming ideas of physical chemistry. But such a broad sweep of ideas —this early speaking of the new language of physical chemistry—may lead to looseness of thought and communication, to lack of rigour and to a false impression of real understanding. Sir Cyril Hinshelwood quotes from Alice: "Somehow it seems to fill my head with ideas—only I don't exactly know what they are".

This problem—this conflict between the synthetic view and appreciation of the subject and detailed and rigorous study—is one which every serious teacher of physical chemistry must face and resolve. The reconciliation of these conflicting ends is in a sense one of artistic presentation. It is an artistic problem; because the subject must be apprehended as a whole, because by touches of the author's brush light and shade must be introduced—the masses of facts, the planes of thought and the tenuous lines of imagination must stand in harmonious relation to one another; and because the work must be stamped with honesty and integrity of thought and understanding. In this sense "The Structure of Physical Chemistry" is a work of art. I would recommend this book to all students of physical chemistry.

The following outline of the scope of the book under notice may indicate the general development of the treatment. The fundamental ideas that matter is made of atoms and molecules, and heat is mechanical motion of atoms and molecules, governed by Newtonian laws, are first introduced. These two ideas, which reached quantitative formulation in the past century, are applied to lead to the numbers and sizes of molecules, their speeds, and the frequency of molecular encounter. The discussion of molecular motion and chaos develops naturally to the introduction of entropy, to statistical mechanics and thermodynamics. Energy at this stage is left as an empirical quantity. But already, very early in the book, the reader has the beginnings of statistical thermodynamics and has heard that most important and recurrent *Leitmotif*—the opposing influences of entropy and energy in chemical equilibrium and change. These ideas are then applied to both physical and chemical equilibria: thermodynamics, statistical mechanics and kinetic theory are used in the discussion, and their essential unities, their various limitations and powers are thus revealed in relatively simple applications.

The furtherance of these questions requires a closer knowledge of the energy states which have already been envisaged in the discussion of entropy; this leads to the introduction of the quantum rules for molecular motion and to the simple evaluation of the partition functions of vibration, rotation and translational motion, and a return to a more detailed discussion of equilibrium and the factors determining its position. But it is not sufficient to accept the energy changes which arise from forces between molecules to give stages of aggregation or, between atoms, to give chemical compounds, as empirical data; and the further investigation introduces the electronic constitution of atoms, the description of states by wave functions and the architecture of atoms and molecules.

The reader is now in a position to be given a more complete discussion of assemblages—of electrons and atoms in metals, of molecules and ions in crystals and in liquids and solutions. He can understand more clearly the ordering effect of van der Waals, Coulomb and valency forces and the opposing effect of random motions. The three fundamental ideas which form the basis of modern chemistry are thus combined: matter is made of atoms, heat is mechanical motion of atoms and molecules, and particles have a wave-like nature.

The equilibrium patterns of chemistry are manifold and varied, but changes of pattern give "vitality and movement to the scene"; and the last section of this book gives a beautiful discussion of chemical changes. Collision theory, transition state theory, thermodynamic analogies, and energy and entropy factors are discussed with clarity, rigour and simplicity; their fields of usefulness in the theory of reaction rates and their limitations are set out. Typical reaction mechanisms are outlined: bond breaking, ionization, atom transfer, electron transfer, energy transfer, chain reactions—and the student is shown how in all these problems our knowledge of valency forces, molecular configuration and motion has made our ideas of chemical changes more precise; and how, here as in equilibrium, ordering into pattern carries with it the concomitant increase of entropy.

This book will give the student the right picture of the subject as a whole; it brings together the various lines of attack, showing clearly their several powers and limitations. It will inculcate rigour of thought and a critical approach—but at the same time will stimulate the student to take up tools which are so attractively presented to him, to sharpen them, and to use them for himself. He will go to his specialist monographs and lectures on thermodynamics, quantum theory or statistical thermodynamics with a proper understanding of their positions and their uses.

The specialist will understand his specialism the better for seeing it set in the subject as a whole.

The research worker will be stimulated to thought and investigation by the problems which are hinted at or are thrown into relief: there is none of the finality of the last word about this book; the inquiry goes on—"that is perhaps the greatest fascination of its adventure".

The book is beautifully written: there are occasional flashes of wit and asides of philosophy—indeed, teaching in its highest form: that sense of intimate conversation with a master. M. G. EVANS

PURE AND APPLIED CHEMISTRY OF ACRIDINE COMPOUNDS

The Acridines

Their Preparation, Physical, Chemical and Biological Properties and Uses. By Prof. Adrien Albert. Pp. xiii+381. (London: Edward Arnold and Co., 1951.) 70*s*. net.

THE investigation of acridine compounds has, in recent years, been to a large extent in the hands of Prof. A. Albert and his collaborators, and it is gratifying to know that the considerable experience which they have gained should now be available, with much else besides, in this volume. To the average student of organic chemistry the subject of acridine is all but a closed book, and the present work should dispel any ideas that may be abroad to the effect that the chemistry of acridine derivatives is dull and uninspiring.

The first eight chapters (Part 1) of the book deal with preparative methods for the synthesis of acridines, acridans and acridones, and it is early apparent that the author has written into its pages a wealth of sound practical experience. A number of preparations, either of acridine derivatives or of essential intermediates, are described at the end of each chapter, and the style is simple and direct, although occasionally a laboratory colloquialism replaces the more formal language of the text-book.

Part 2, also of eight chapters, discusses physical and chemical properties of acridines, preparation and properties of substituted acridines, aminoacridines, quaternary acridine derivatives, reduced acridines, acridones, thioacridones and binuclear derivatives. The degradation of substituted 5-aminoacridines in alkaline solution with hydrogen sulphide, noted by Hammick and his pupils, is not specifically mentioned although the reference is given in a misleading context. Apart from this slight criticism, the first two sections of the book are written in a balanced and critically objective manner.

The first chapter of Part 3, dealing with the utilization of acridines in clinical medicine, has been written a little more enthusiastically and somewhat less objectively than preceding and later chapters. Obviously Prof. Albert sees in the acridines a potential source of valuable drugs in addition to mepacrine and the existing aminoacridine antiseptics; for he asks the leading question (p. 234), "Have the possibilities of using acridines in therapy been exhausted?" and adds, "The answer is most emphatically no", going on to say that ". . . the clinical possibilities of 'the acridines' are potentially as fertile as those of 'the benzenes' (which recently contributed sulphanilamide, *p*-aminosalicylic acid and chloramphenicol)", although it is conceded "that, as with other nuclei, the acridine ring contributes only a fraction to the biological action of its derivatives". Part 3 continues with a stimulating chapter on chemical constitution and antibacterial action; but the chapter dealing with the antimalarial action of acridine derivatives would have gained somewhat in perspective by even brief mention of chloroquine, which is derived, at least in theory, from mepacrine by ablation of one of the benzene rings.

The remaining chapters of the book cover tinctorial properties of acridines, the connexion between constitution and colour in the acridine series, and fluorescence and chemiluminescence among acridines. The work ends with a really excellent reference and author index, together with a good subject index and an index to the preparations described.

The author is to be congratulated on the completeness with which he has covered his subject and on his ability to write authoritatively and with equal facility on so diverse a range of specialized aspects of pure and applied organic chemistry. Most organic chemists and many biologists will find much to interest them in this volume, and its well laid-out tables, ninety-nine in all, will save many time-consuming searches in the literature for data on acridine and its derivatives. All concerned with the production of this book, author, printers and publishers, may derive satisfaction from the certain knowledge that their work will be gratefully received by a wide range of readers. J. WALKER

SPIDERS OF BRITAIN

British Spiders

By G. H. Locket and Dr. A. F. Millidge. Vol. 1. (Ray Society Vol. 135 for the Year 1949.) Pp. ix+310. (London: Ray Society, c/o British Museum (Natural History), 1951.) 27*s*. 6*d*.

SEVENTY years is a long time to wait for a book, and yet Pickard-Cambridge's "Spiders of Dorset", published in 1881, was, until now, the latest attempt to describe all the spiders of Britain. The absence of a recent book of this kind has been felt more and more seriously for more than half a century: now at last help is forthcoming in this the first of two volumes from the Ray Society. It is a work on which the authors, Mr. G. H. Locket and Dr. A. F. Millidge, who speak with the voice of experience and authority, can be unreservedly congratulated.

The opening chapter, a contribution from Dr. W. S. Bristowe, is a historical account of the study of British native species, in which Bristowe appreciatively surveys the work of his predecessors. He happily takes notice of their individual qualities and makes a human story of what might have been a dull record of specialized zoology. Wisely he emphasizes again the fact that nearly all our knowledge of British spiders is due to the devotion of men otherwise engaged on their own professional duties, while the British Museum (Natural History), for more than forty years, has sacrificed spiders to mites.

Mr. Locket and Dr. Millidge have tackled their systematic and descriptive problem in an engagingly workman-like manner. After the customary paragraphs on collecting and preserving spiders, and an account of their external features which is, perhaps, rather longer than necessary, they print a dichotomic key to twenty-four British families, with adequate illustrations and the addition of fifteen very helpful 'notes'. The families follow in turn, each with a summary of its characteristics, a key to its genera, and descriptions of its species.

Diagnostic work of this kind can never produce dramatic writing: a reviewer can but look for the underlying principles and try to judge the help afforded to readers who, less familiar with the animals themselves, are trying to name spiders from these pages. In so doing I find, first, descriptions which emphasize the essentials and are not overburdened with repetition and detail. Blackwall's description in 1861 of the common species *Xysticus cristatus* occupied a thousand words; Locket and Millidge are more practically helpful in two hundred. They tell their readers exactly what to look for in each species, and give accurate drawings of genitalia and other features that they may expect to see. British araneology has never before had anything like this; within its own sphere it is an outstanding contribution to taxonomy.

Because of this it is unfortunate that, while most of the admirable drawings have been clearly reproduced, some have not reached the high standard that we have become accustomed to expect in Ray Society volumes. Fig. 21 (*Ciniflo similis*) is an example of this: the fault lies not with the artist but in the process of reproduction, and is particularly regrettable.

The notes on the distribution of each species are ecological in character, not geographical. Here again, it is on the practically helpful information that the emphasis has fallen. This volume, which covers 205 species in seventeen families, has not reached the Linyphiidæ, the most 'difficult' group, but it includes several of the genera in which separation of the species is sufficiently puzzling. One turns to these genera—*Lycosa* and *Clubiona* are examples—with interest, and finds the same practical guidance, the genera being conveniently split into groups and the contrasting characteristics of closely related species displayed in tabular form.

As I have said, this book was badly wanted and has not disappointed me. I look forward to its successor with keen anticipation of even greater satisfaction.

T. H. Savory

DYNAMICS FOR MATHEMATICIANS

Advanced Dynamics

By E. Howard Smart. Vol. 1: Dynamics of a Particle. Pp. xi+420. Vol. 2: Dynamics of a Solid Body. Pp. xi+420. (London: Macmillan and Co., Ltd., 1951.) 40*s*. net each Vol.

IN these days a book on dynamics rarely describes recent discoveries; it is normally a presentation of long-established facts. It is to be classified according to the class of student for whom it is written, and the clarity and interest of the presentation. The recent work by the late E. H. Smart, entitled "Advanced Dynamics", is for mathematical students (though not wholly for honours mathematicians) and embodies the substance of lectures given to students preparing for London degree examinations. It begins at first principles; but it is not a beginners' book, since even in the first chapters more advanced ideas appear side by side with the elementary ones. The first volume covers such parts of particle dynamics as can be discussed without using generalized co-ordinates. The second deals with rigid dynamics in two and three dimensions, including a full treatment of Lagrange's and Hamilton's equations, but omitting other more advanced analytical topics. Within these limits, the whole forms a full and comprehensive treatise.

It is the book of a teacher. No pains are spared to enable the student to apply dynamical principles. Dozens of examples are worked in the text; and the collections of examples for the student are long and numerous. On the other hand. the discussion of physical principles occasionally leaves something to be desired; subjects of more formal interest—for example, the motion of chains, impulsive motion, and initial accelerations and curvature—are discussed more fully; and the emphasis of the treatment sometimes suggests that the need of getting students through examinations had an undue influence.

The presentation shows the marks of a lecturer; it is bright and interesting, discursive, a little unsystematic, and not infrequently repetitive. It shows that disregard for pure mathematical niceties (especially as regards differentials and limits) which often characterizes lecturers in applied mathematics; it is noteworthy, however, that lax statements are not permitted in proofs on which examination questions can be set. Vector ideas are frequently used, but in an unsystematic manner, the basic results being proved over again for new vectors. I should have preferred to have seen more discussion of the use of complex numbers in oscillatory problems, and of those parts of dynamics used in quantum mechanics. An interesting feature is the historical notes given in the text and at the end of some of the chapters.

The work was produced under difficulties, and the publishers deserve credit for the pertinacity through which it was finally produced. E. H. Smart died in 1945; Mr. F. G. W. Brown undertook the final revision of the manuscript and read most of the proofs; he died in 1949, and his work was finished by a colleague. Partly because of this, the book (especially the first volume) contains a number of slips and misprints, sometimes surprisingly ingenious ones. More unfortunate are a number of actual errors or unsound statements, particularly in Chapters 4 and 9 of the second volume; and an occasional lack of co-ordination between the different sections. Because of these, one would hesitate to recommend the book to a student working by himself; but it is one which teachers of the subject ought to possess.

T. G. COWLING

AN APOSTLE OF HUMUS

The Weed Problem

A New Approach. By F. C. King. Pp. xii+164. (London: Faber and Faber, Ltd., 1951.) 8*s*. 6*d*. net.

MR. F. C. KING is the Don Quixote of the self-styled "apostles of humus". He tilts at windmills, with a fervid belief in their aggressive antagonism. He displays the same half-bewildered air of sweet reasonableness alternating with fierce resentment against those who, in his mind alone, dare to seem to disagree with the central article of his faith. His new publication, though ostensibly concerned with the virtues of weeds in gardens, is but a thinly-veiled reiteration of the "muck-and-mystery" creed. It is astonishing that the upholders of this faith seem entirely unable to believe that soil scientists and plant physiologists can see any value in organic material in the soil. To them, the soil scientist is one who advocates the use of inorganic fertilizers alone for the maintenance of soil fertility and, above all, the use of sulphate of ammonia, that *anathema maranatha* of the "composters". One can only charitably conclude that they read solely within their own circle and are unable, therefore, to appreciate that the soil scientist attributes just as great importance to humus-forming materials as they do themselves but for different and more logical reasons. They persist in the view that inorganic fertilizers and organic manures are opposite and alternative instead of being, as the scientist appreciates, complementary.

Although they cannot themselves see it, the whole matter has become for them a cult, an esoteric mystery, in which Nature occupies the theistic role. Their favourite phrase, used repeatedly in Mr. King's book, is "the immutable laws of Nature", and the greatest crime is to transgress these laws, which appear to have been revealed to them alone.

Mr. King's theme in the present book is that we must "preserve the earth's green carpet in accordance with the immutable law of Nature which demands a covering for all fertile land", and this is to be achieved by "controlled weed growth" within the crops. There is much vague and loose discussion of "symbiosis" between weeds and crop plants which abundantly confirms the conclusion that the author has rarely read and certainly not understood scientific publications. Perhaps most astonishing of all is the author's method of explaining away facts contrary to his views by unjustified assumptions from untested premises.

The author gives no really clear-cut practical directions for the application of his ideas on weed control combined with no-digging, but patient seeking through the book brings one to the conclusion that basically his notion is little more than the principle of green manuring with surface-cultivation such as is achieved by rotary tillage, though this latter method is never specifically mentioned. He has obviously thought deeply and observed closely, but lacks the background of knowledge correctly to interpret his observations.

R. H. STOUGHTON

TECHNOLOGY OF DEFECTS IN PAINTS

Paint Film Defects

Their Causes and Cure. By Manfred Hess. Pp. xvii+544+65 plates. (London: Chapman and Hall, Ltd., 1951.) 50*s*. net.

THIS book is the first English edition of the original German book published in 1938; but the present volume has been brought well up to date. Its very title will arouse interest among those who are concerned with the many diverse problems associated with paint deterioration, for, as the author says, "it is the first extensive collection of paint failures ever made". On first consulting this book in a general way one is at once impressed not only by the large amount of effort and time expended in the collection of the necessary material, but also by the thought given to the classification of the experimental results. When, however, one settles down to study a selected topic—following the instructions thoughtfully provided by the author for finding one's way through the labyrinth of possibilities—one realizes that while each topic is discussed exhaustively in all its aspects, the book is essentially practical and not scientific in its approach. It is for this reason that one feels that a word of caution must be given to those readers not versed in scientific methodology. The author has not been discriminating in his selection of the experimental evidence; a host of really useful information based on sound scientific evidence tends sometimes to become smothered by statements of a more superficial character, sometimes contradictory and often open to query. Apart from this criticism, the book is an excellent one; the author is to be congratulated upon its production, as it fills an important gap in the bibliography dealing with paint and allied subjects.

The subject-matter is considered under four main headings, divided into sections, dealing respectively with faults which may develop during storage, during application, shortly after application, and on finished objects when in use. There is also a useful postscript giving an alphabetical list of terms and definitions connected with paint failures. The bibliography is good and the indexing and cross-references—on which the practical value of the book ultimately depends—are extremely thorough. Errors arising from translation are very few, and the book is also remarkably free from misprints. It is a work which cannot be read conveniently section by section, since there is no continuity. It is essentially a reference book, and as such can be strongly recommended as a convenient *vade mecum* for a wide circle of paint technologists.

A. E. A. WERNER

Thorpe's Dictionary of Applied Chemistry

Fourth edition, revised and enlarged. Vol. 10: Plagioclase—Sodium. Pp. xi+913. (London, New York and Toronto: Longmans, Green and Co., Ltd., 1950.) 100*s*. net.

WITH the advent of the letter "S" in the tenth volume of the new edition of "Thorpe's Dictionary of Applied Chemistry", the editorial board is within sight of the end of its vast undertaking. One further volume ("SO to Z") and a general index will complete the work. The Dictionary does more than give the latest information on plagioclase, sodium and the rest: it epitomizes the present vitally intimate relation between the science of chemistry and its application in technology. The articles have been contributed almost equally from universities and from the chemical and allied industries. They emphasize that advances in chemical technology are now dependent on and inseparable from advances in chemical science, and will only be made by trained scientific workers. This is a lesson of paramount importance to-day when higher technological education is so much under discussion. There is no short cut to the best technology: it can only grow out of the best science.

The level of the articles has been kept remarkably high. Indeed, I cannot remember a volume of 'Thorpe' so full of informative and interesting material. The editors have made an admirable choice of contributors; to choose at random: Wilson Baker on plant pigments; Bate-Smith on preservation of meat by drying; Brock on pyrotechny; Kellaway on snake venoms; A. R. Powell on platinum; Simonsen on pulegone and other terpene subjects, and so on. Symbolically, there are two excellent articles on rubber—one from a strong British team on natural rubber, and one from an equally strong American partnership on synthetic rubber. Another admirable article is that on quinones by a team from the Dyestuffs Division of Imperial Chemical Industries, Ltd.

To sum up, this is an altogether excellent production giving a vast amount of up-to-date information in a clear and understandable form, and at a reasonable price. A small point may be mentioned: Could something be done to make more obvious the authorship of the individual articles? True, the reader has the necessary clues to enable him to solve the mystery; but is there any need for a mystery?

R. P. Linstead

Annual Review of Physical Chemistry

G. K. Rollefson (editor), R. E. Powell (associate editor). Vol. 1. Pp. viii+382. (Stanford, Calif.: Annual Reviews, Inc., 1950.) 6 dollars.

THIS "Annual Review of Physical Chemistry" makes its début in a volume of eighteen chapters covering a considerable area of the domain of physical chemistry. The majority of the articles are restricted to developments occurring in the period 1948–49 (for example, radiation chemistry, spectroscopy, X-ray structural crystallography, chemical kinetics, photochemistry), but others review more than the past decade (for example, thermochemistry, radioactivity and nuclear theory, theories of valence, experimental molecular structure, statistical mechanics of the crystalline and liquid states).

The articles reflect the modern tendency of physical chemists towards specialization in a particular branch of the subject, for few readers will be able to assimilate the full content of this book in detail. Yet the careful reader will find that the ideas and techniques of one field of specialization often overlap with and have application in another, so that, paradoxically, he advances his own specialization by a knowledge of some other.

Excluding the section on thermochemistry—which is not a review but a remarkable and invaluable bibliography of 825 references—the individual articles achieve a careful delimitation on their choice of material. In consequence, overcrowding is avoided, and criticism and emphasis have not been sacrificed—as witness, for example, the articles by Crawford and Mann on spectroscopy, Beach on molecular structure, Daniels on chemical kinetics, and Longuet-Higgins and Wheland on theories of valence.

This new series of "Annual Reviews" has made a promising beginning, and physical chemists generally will find it useful and stimulating.

H. A. Skinner

Geschichte der Chemie in kurzgefasster Darstellung

Von Prof. Dr. Georg Lockemann. Band 1: Vom Altertum bis zur Entdeckung des Sauerstoffs. (Sammlung Göschen, Band 264.) Pp. 142+4 plates. (Berlin: Walter de Gruyter und Co., 1950.) 2.40 D. marks.

THIS small book gives a very interesting and competent survey of the history of chemistry from the earliest times to the discovery of oxygen. The author is known for his articles on the subject in German chemical journals and has an excellent knowledge of recent publications on the history of chemistry. His text is therefore based on recent investigations. The amount of information given is quite surprising when the size of the book is considered, and there are eight portraits on art paper at the end. The bibliography contains exclusively German books, and there is not space for detailed references. Some names are given incorrectly, and as these errors are distributed impartially among nationalities, including German, it must be assumed that they are due to careless proof-reading and may be corrected in later printings of this very useful little work.

J. R. P.

Electronics

By P. Parker. Pp. viii+1050. (London: Edward Arnold and Co., 1950.) 50*s*. net.

THE scope of a course on electronics has undergone a gradual change during the past fifteen years. Before the War what was required was, in general, an introduction to radio communications engineering. In a text-book on this subject one expected to find a brief introduction on electron tubes or radio valves, followed by a discussion on power supplies, amplifiers and oscillators. Propagation of electromagnetic waves and aerial systems would be dealt with fully, and finally a few typical circuits of receivers and transmitters would be examined.

The present volume makes, and needs, no apologies for the fact that the words electromagnetic waves, automatic volume control and telegraphy do not appear in its index. It is intended as an introduction to the physics of electron tubes, and circuits are dealt with only so far as they illustrate the properties of the tube. Vacuum and gas-filled tubes of great diversity are dealt with, including cavity magnetrons, on one hand, and Geiger counters, on the other. Throughout the book there is an emphasis on the physics of the devices considered: thus there is a good introduction to electron optics.

The book is stated to require no more than an advanced school knowledge of physics, and this accounts for explanatory notes on, for example, the Bohr atom and kinetic theory. There are good bibliographies with suggestions for further reading at the end of every chapter, and exercises with answers to numerical problems are provided.

U. W. ARNDT

Electricity and Magnetism

Classical and Modern. By Dr. G. B. Deodhar and K. S. Singwi. Pp. viii+507. (Allahabad and Benares: Students' Friends, 1949.) 15 rupees.

THE authors, who are members of the staff of the Physics Department of the University of Allahabad, have covered the main topics in the subjects of electricity and magnetism at a level which is adequate for a pass degree in physics. Some of the material included, such as Maxwell's electromagnetic equations, goes beyond the usual range of a pass degree course, but generally the treatment is neither sufficiently advanced nor sufficiently comprehensive to meet the full needs of an honours course in physics.

The book is divided into two sections, classical and modern. The classical section covers the usual field, particular prominence being given to measuring instruments and their uses. The modern section outlines the subjects of the conduction of electricity through gases, electronics, positive ray analysis and isotopes, atomic structure, X-rays, photoelectricity, natural radioactivity, artificial transmutation of elements, electron waves, cosmic rays, terrestrial magnetism and atmospheric electricity.

The book is lucidly written and well illustrated, and because emphasis is laid on experiments and physical concepts it should appeal to students with limited mathematical attainments. The quality of the printing and the trimming of the pages leave much to be desired.

A. H.

Die elektromagnetische Schirmung in der Fernmelde- und Hochfrequenztechnik

Von Dr. Heinrich Kaden. (Technische Physik in Einzeldarstellungen, herausgegeben von W. Meissner, Band 10.) Pp. viii+274. (Berlin, Göttingen und Heidelberg: Springer-Verlag; München: J. F. Bergmann, 1950.) 38 D. marks.

AS is justly remarked in the preface, no collected and systematic presentation of the principles of electromagnetic screening has hitherto been available. The author, with his long experience in these problems at Siemens-Halske, has been successful in filling the gap with this present book. Though the approach is essentially theoretical, it is concise and thorough and contains material, much of which is new, and most of which will prove valuable to the communications engineer who is concerned with screening at audio and radio frequencies.

The first part, "Screening against Disturbing Fields", which lays somewhat more emphasis on magnetic than on electric screening, deals with both closed and open screens and with the effect of slits, holes and gaps. Screening by grids and meshes of wires is only rather briefly treated. The second part, "Screening against Disturbing Currents", is concerned with undesired pick-up on the inner conductors of a cable due to imperfections of conductivity or continuity in the outer screen and with cross-talk between cables.

There is a short appendix which summarizes the properties of Bessel and Legendre functions and gives a selected bibliography of forty-nine references. A moderate level of mathematical knowledge in the reader is assumed, but the author has been careful to introduce and develop the techniques in a manner which is readily applied to similar problems having different boundary conditions.

R. E. BURGESS

L'Analysis situs et la géométrie algébrique

Par S. Lefschetz. (Collection de monographies sur la théorie des fonctions.) Pp. vi+154. (Paris: Libr. Gauthier-Villars, 1950.) 650 francs.

THIS reprint restores to currency one of the most famous of the Borel tracts. The study of algebraic functions of a single variable rested securely on the pillars of function theory and topology, but the extensions and generalizations to higher dimensions were unsatisfactory until Lefschetz took the whole matter in hand; his investigations up to 1924 are summed up in this volume—not altogether easy reading and in places displaying some of the roughness of pioneering work, but full of ideas and brilliantly stimulating. The central position of topological notions in the field of algebraic geometry is clearly brought out in studying algebraic surfaces, systems of curves on algebraic surfaces, algebraic varieties, and the related Abelian integrals. From this guiding clue much of the very considerable progress made during the past twenty-five years in the domain of algebraic geometry has arisen. An account of this progress is to be found in Prof. W. V. D. Hodge's presidential address to the London Mathematical Society in 1949 (*J. Lond. Math. Soc.*, 25, Part 3; July 1950), in which the great debt owed to Lefschetz by all algebraic geometers is fully acknowledged. The impact of Lefschetz's contributions on the topic is so weighty that his tract, even in unrevised form, is still an indispensable text for the serious student of the subject.

Functional Operators

By John von Neumann. Vol. 1: Measures and Integrals. (Annals of Mathematics Studies, No. 21.) Pp. vii+261. (Princeton, N.J.: Princeton University Press; London: Oxford University Press, 1950.) 22*s*. 6*d*. net.

THE general mathematical theory of operators has been much advanced by von Neumann's lectures at the Institute for Advanced Study, Princeton, now printed in the "Annals of Mathematics Studies". The first volume is almost entirely devoted to the theory of integration, which is given in a completeness probably beyond what will be required in the second and succeeding volumes.

About one-third of the book deals with the theory of Lebesgue measure and integration, in n-dimensional spaces, giving a concise and fairly comprehensive account of the basic concepts and theorems on the Lebesgue integral. The rest of the book is divided about equally between two chapters, one of which generalizes the measure theory to abstract spaces, and incidentally provides a definition of the Lebesgue integral independent of the topological ideas usually involved; the last chapter gives a thorough discussion of the general integral, and deals in detail with the derivative of one set function with respect to another.

The whole treatment is detailed, accurate and painstakingly thorough. It will, of course, appeal only to the pure mathematician with a taste for abstract spaces, but to such a reader the exposition will present no great difficulty.

ARCTIC AEROBIOLOGY

POLLEN GRAINS AND OTHER SPORES OBSERVED ON STICKY SLIDES EXPOSED IN 1947

By Prof. NICHOLAS POLUNIN
McGill University, Montreal*

PREVIOUS communications on this subject have been mainly concerned with preliminary explanations and observations[1] and with the fungi and bacteria[2] which colleagues were able to isolate from colonies developing on nutrient plates that I exposed when flying northwards to the Arctic Ocean and the vicinity of the North Magnetic Pole in 1947. Already in the first paper it was explained how, in conjunction with each such exposure, a 'Vaselined' microscope slide was so held in a specially constructed wood and metal holder that ". . . the sticky surface was exposed against the air-stream for five minutes in about the same position outside the aircraft as the nutrient plate", and a subsequent communication[2] mentioned that, ". . . on some of the slides exposed near the Arctic Ocean coast there are represented spores of three of the most important airborne pathogens of cereal crops of Canada, namely, wheat stem-rust (*Puccinia graminis tritici*), wheat leaf-rust (*P. rubigo-vera* = *P. triticina*), and foot-rot of barley and rye (*Helminthosporium sativum*)".

It is the object of the present paper to give numerical and other details of the findings, by direct microscopic observation, of pollen grains, pteridophytic and bryophytic spores, and the spores of pathogenic or other fungi, that proved to be present on these slides which I exposed on the four air sorties described in the next paragraph, and which were early sent for examination to Dr. B. Peturson, Dominion Laboratory of Plant Pathology, Fort Garry, Manitoba, and to Dr. N. W. Radforth, of McMaster University, Hamilton, Ontario. To these two workers, and their assistants, my warm thanks are due—as also to Dr. Roger P. Wodehouse, of the Lederle Laboratories, Pearl River, N.Y., for further help and his expert guidance particularly in the matter of pollen grains. I would also like to take this opportunity of acknowledging indebtedness to the Royal Canadian Air Force for the splendid facilities afforded, and of expressing personal admiration for my two friends and principal pilots, Flight-Lieutenant J. F. Drake and Squadron-Leader William Carr.

The four sorties on which the exposures were made in 1947 were as follows: (1) on August 12 in a single-engined 'Norseman' aircraft from an unnamed lake (which I called Canso Lake, lying north-west of Great Bear Lake) in a northerly direction to Langton Bay on the Arctic Ocean coast, and thence in a north-westerly direction to the mouth of the Horton River near Cape Bathurst, the most northerly point of the western Canadian mainland; (2) on August 26 in a twin-engined 'Canso' flying-boat from Cambridge Bay, Victoria Island, in a north-easterly direction to the southernmost extremity of Somerset Island, then northwards until bad weather intervened in about latitude 73° N.; (3) on August 27 in the same flying-boat from Cambridge Bay in a south-south-westerly direction to Yellowknife, Northwest Territories; (4) on September 5 in the same flying-boat almost due south to Edmonton, Alberta. These routes were indicated on a sketch-map in the first communication[1], and the approximate positions of exposure were spotted in the second paper[2], which also indicated the approximate times of exposure, airspeeds, geographical co-ordinates, and altitudes. The positions of exposure are more accurately indicated in the accompanying sketch-map (Fig. 1), on which the Roman numerals refer to the individual sorties. With the altitude generally around one mile and the airspeed some 100 knots (115 m.p.h.), an attempt was made to expose a fresh slide and plate every twenty air miles during the first two sorties, and every thirty air miles during the third and fourth; but bad weather, icing, and preoccupation with landing and my other duties resulted in some irregularity and particularly lengthy gaps at the beginnings of flights 3 and 4. Apart from these gaps, it was possible to obtain an almost unbroken transect in the form of these periodical exposures extending over some 1,500 miles from the vicinity of the North Magnetic Pole to Edmonton, Alberta—besides the 'preliminary' northwards to the Arctic Ocean coast farther west.

The results as well as other pertinent data are indicated in the accompanying table, which scarcely requires explanation except as regards the unfortunately high proportion of uncertainties among the pollen grains and bryophytic spores, particularly; they are due to discrepancies between the observa-

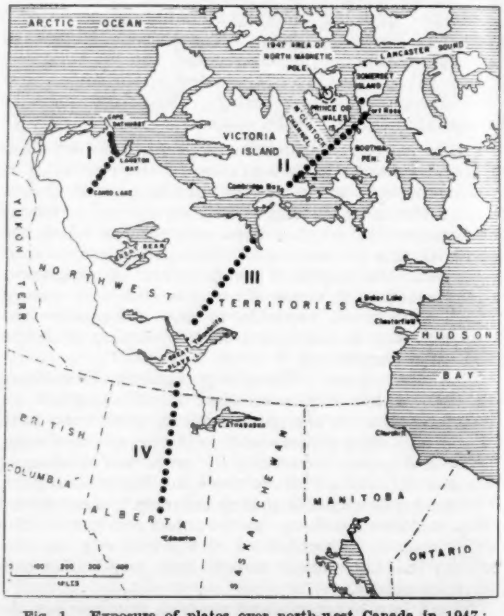

Fig. 1. Exposure of plates over north-west Canada in 1947; Roman numerals refer to individual flights

* Now on leave of absence with a Guggenheim Fellowship and Honorary Research Fellowship at Harvard University, Cambridge, Mass. This paper was prepared during the winter of 1949–50; but the results here published were not fully cleared until more than a year later. In the meantime an account of part of the same material has been published independently in *Phytopathology* (**40**, 632; 1950). (Footnote added in proof.)

POLLEN GRAINS AND SPORES OBSERVED ON 'VASELINED' SLIDES EXPOSED OVER NORTHERN CANADA 1947

Slide No.	Pollen grains, etc., per slide (doubtful totals in brackets)				Identified fungal spores per slide					
	Angio-sperms	Gymno-sperms	Pteridophyta	Bryophyta	Stem rust	Leaf rust	*Alternaria* spp.	*Helminthosporium* spp.	Smut	Other
Flight I, from Canso Lake to Cape Bathurst (slides 1–11), August 12. Fair 9/10 overcast (ceiling 5,000) at start. Air-mass coming from N.W. after travelling E. over ocean										
1	—	—	1	(? 5)	—	1	2	1 *H. sativum*	—	2
2	(? 1)	—	—	—	1	—	—	1 *H. sativum*	—	1
3	(? 2)	—	—	(? 2)	—	—	—	—	—	1
4	—	—	—	(? 1)	—	—	1	2 *H. sativum*	—	—
5	1	—	—	—	—	—	—	—	—	—
6	1	1	—	—	—	—	—	—	—	—
7	—	—	1	—	—	—	—	—	—	1*
8	—	—	1	(? 1)	—	—	—	—	1	1*
9	—	1	—	—	—	—	—	—	—	2
10	—	—	—	—	—	—	1	—	—	1
11	1	—	1	(? 3)	1	—	—	—	—	3
Flight II, from Cambridge Bay to Somerset Island (slides 13–27), August 26. At start 9/10 low cloud; high overcast as well. Strong N.W. wind on ground; air-mass in south coming from N.N.W. and towards northern end of flight from N. after sweeping around from E. In both cases apparently of arctic Canadian origin										
13	1	—	(? 1)	—	—	—	—	—	—	3
14	—	—	1	—	—	—	—	—	—	—
15	(? 1)	—	—	—	—	—	—	—	—	—
16	(? 1)	—	—	—	—	—	1	—	—	—
17	—	—	—	—	—	—	—	—	—	—
18	—	—	—	—	—	—	—	—	—	—
19	—	—	—	—	—	—	—	—	—	—
20	—	—	—	—	—	—	1	—	—	—
21	1	—	—	(? 1)	—	—	—	—	—	—
22	—	—	—	—	—	—	—	1 *H. sativum*	—	—
23	—	—	—	—	—	—	—	—	—	—
24	1	—	—	—	—	—	—	—	—	—
25	—	—	—	—	—	—	—	—	—	1
26	—	—	—	—	—	—	—	—	—	—
27	—	—	—	(? 1)	—	—	—	—	—	—
Flight III, from Cambridge Bay to Yellowknife (slides 28–39), August 27. Wind westerly on ground at start; continuous low cloud but flew above. Air-mass coming from N.N.W. in north, apparently of arctic Canadian origin, but from N.W. towards southern end of flight										
28	—	—	—	—	—	—	—	—	—	—
29	—	—	—	(? 1)	—	—	—	—	—	—
30	—	—	—	—	—	—	—	—	—	—
31	—	—	—	—	—	1	—	—	—	—
32	—	—	—	—	—	1	—	—	—	—
33	—	—	—	—	—	—	—	—	—	—
34	—	—	—	—	—	1	—	—	—	—
35	—	1	1	—	—	—	—	—	—	2
36	—	—	—	—	—	—	—	—	—	—
37	—	—	—	—	—	—	3	1 *H. sativum*	—	2
38	(? 1)	—	—	—	—	—	—	—	—	—
39	(? 1)	—	—	—	—	1	—	—	—	1
Flight IV, from Yellowknife to Edmonton (slides 40–53), September 5. Winds easterly for past 12 hours on ground at Yellowknife. Air-mass in north variable but apparently of southern origin (*see* text), in middle of flight coming from W.N.W. (presumably Alaskan origin), and in south coming from W.										
40	2	(? 1)	12	3 (? 14)	20	74	—	—	1	18
41	(? 2)	—	19	1 (? 4)	23	68	1	—	34	34
42	—	—	6 (? 7)	2 (? 3)	4	14	1	—	9	3†
43	(? 2)	—	—	—	—	1	—	—	—	—
44	—	—	—	—	—	—	—	—	—	—
45	—	—	—	—	1	4	—	—	—	1
46	1 (? 4)	—	1	1 (? 3)	4	20	—	—	—	3
47	(? 2)	—	2	(? 9)	4	24	1	—	—	—
48	(? 1)	—	3	(? 9)	3	9	—	1	38	4
49	—	2	3 (? 4)	(? 4)	4	29	—	1	29	37
50	(? 3)	—	1	3 (? 11)	4	7	1	—	21	36
51	(? 3)	—	1	3 (? 5)	—	14	—	1	10	9
52	(? 1)	—	5	(? 5)	2	14	4	7	30	80
53	—	1	1	(? 2)	4	11	4	5	2	99

* Probably *Cladosporium* sp. † Including one teliospore of *Puccinia* sp.

tions of different specialists who were either looking for other things or trying valiantly to observe without staining (for fear that treatments planned for the future might be precluded by such an operation). It is also possible that some of the grains had been accidentally removed in the meantime, for the slides were loose in their individual, though well-wrapped, containers. In all, fifty-two slides were exposed (No. 12 was omitted) and their full re-examination in this connexion was not attempted—more because it would have been of doubtful validity in view of all that the slides had by then been through than because of the considerable labour involved.

Although the results given in the table seem practically to speak for themselves, a few items are considered worthy of comment; nevertheless, it should be emphasized that it would be dangerous to generalize except perhaps in the most tentative manner from such limited experiences and relatively few observations as these preliminary studies afford.

(1) These observations evidently confirm the presence of pollen grains and the spores of Pteridophyta and pathogenic fungi in the air above remote treeless and even ice-bound regions northwards at least beyond the seventieth parallel of north latitude—cf. Meier and Lindbergh[4], whose "Fig. 12. Types of objects trapped above the Arctic Circle on slide 15" ("exposed on August 6 for forty minutes at an average altitude of 3,000 feet above sea level over the coast of Greenland between Scoresby Sound and Clavering Island, north of 70 degrees latitude" in 1933) appears to include items representative of each of these three categories. Unfortunately these authors' promised detailed results were never published, owing to Meier's untimely death, and I have been unable to

locate any of their material—at least, in a suitable state for working out.

(2) On the earliest flight, the northernmost catch of a winged pollen grain of a coniferous plant was made in latitude 69° 28′ N., which is well north of the nearest likely source (cf. the recent report by Dyakowska[5] of their persistence in the air near sea-level off the west coast of Greenland at least as far north as the vicinity of Godthaab (lat. 64° 11′ N.), although in this case, in spite of the lower latitude, the nearest likely source was much more distant).

(3) Spores of various all-too-familiar pathogenic fungi were found far north of their probable nearest point of origin—in the case of uredospores of wheat stem-rust to 70° 02′ N. at a point which, as already reported[3], ". . . is the better part of 1000 miles north of the Peace River region, which is the nearest likely source of supply of any real extent, and would seem to extend remarkably the much-cited 'at least 200 miles' that spores of [this] important parasite (which alone has caused an estimated loss in western Canada through injury to the Wheat crop of as much as $200,000,000 in a single year) are known to have been disseminated". Although with these small numbers the possibility of error due to contamination is by no means ruled out, the general conditions and controls and other observations suggest that it is slight and indicate the probable validity of these results. So supposedly there is frequent danger of infection as a result of such long-distance dispersal, though it may be noted that the positive and plentiful smut spore observations were practically limited to the two air-masses of supposedly southern Canadian origin—*see* (6). Indeed, the only exception identified is expressly noted by Dr. Peturson as "not a cereal Smut . . . possibly a grass Smut" (a considerable range of Ustilaginales parasitize Cyperaceæ, Polygonaceæ, etc., very plentifully and widely in the Canadian Arctic as noted by Linder[6]).

(4) Although spores of *Helminthosporium sativum* and *Alternaria* spp. (not necessarily pathogenic) were very widespread, they appeared to be relatively sparse; the only counts at all high of spores identified on these slides were obtained on the southernmost flight and involved chiefly stem and leaf rusts and smuts, which alone assumed numbers suggestive of epidemic conditions (cf. the mimeographed Twenty-seventh Annual Report of the Canadian Plant Disease Survey, 1947). It is also mainly in the southernmost forested regions that other bodies, including the spores of Pteridophyta and Bryophyta, appear to have become relatively plentiful—possibly suggesting loss by gravitational sedimentation or removal by precipitation to the north, although the high counts of rusts and smuts from not so far south of Yellowknife as to be still well north of the belt of widespread cultivation would seem to indicate that such loss is not necessarily rapid. One is apt to get a picture of sweeping gusts and upward air-eddies in the sun-heated, cultivated plains of the south carrying disseminules to high altitudes—at which they may travel northwards on strong winds until they meet a cold front, for example, when precipitation contingent on this meeting may remove them from the air, or, if it does not, turbulence will be likely to confuse the issue. Farther north, in the real Arctic, the precipitation tends to be very slight and the winds almost perpetual, so that any particles which lie aloft in the atmosphere may be expected to stay up for a long time. What proportion remains viable under the radiation and other conditions obtaining, and for how long, might be worth investigating, though at present it seems likely that ultra-violet radiation may be less harmful to micro-organisms in the Far North than to the south.

(5) Actually, the probable explanation of the high counts on the first three slides exposed after leaving Yellowknife is that I was then flying in a different air-mass from that encountered thereafter—with such surprising rapidity that I noticed the marked temperature rise on my hand as I put it out to make the fourth exposure. Warm air persisted throughout the remainder of the flight to Edmonton, and according to the trajectory analyses kindly furnished by Mr. K. T. McLeod, of the Air Services Meteorological Division, Department of Transport, Canada, was of south Alaskan origin in its northern part and almost due westerly in its southern part. But only this southern part of the warm air of westerly origin had come over much southern, cultivated land; and it was this southern part which gave most of the high counts. The other high counts were afforded by the first three slides exposed on this last flight, and it is remarkable that the trajectory of this air-mass, although it was travelling eastwards just then, indicated that it had so swept around that eighteen hours previously it was travelling westwards some two hundred miles to the north and, a few hours before that, had been much farther to the south-east—with some indication of having previously come over the cultivated prairie regions like much of the air encountered near Edmonton. The air-mass trajectories for this fourth flight are indicated in Fig. 2. The correlation in this case is extraordinarily close, and is supported by the spores of the higher plants as well as those of fungi; thus whereas on the first three slides exposed after leaving Yellowknife (Nos. 40–42, while I was in air of probably southern origin) there were found no less than 349 identifiable spores, etc., on the next three (Nos. 43–45, exposed in Alaskan air) there were identified but seven, and six of these were on the sixth slide (No. 45),

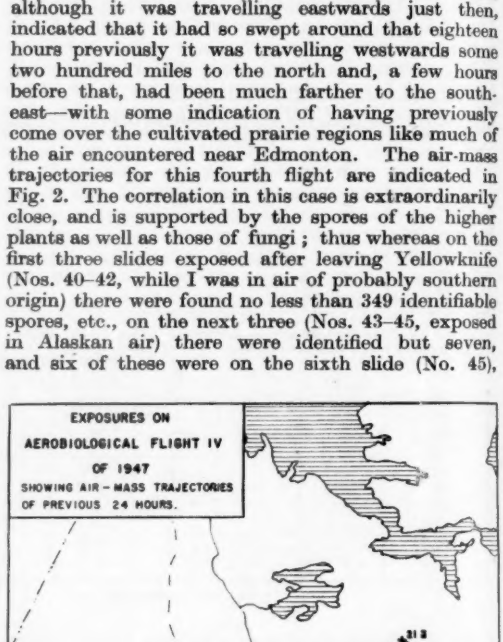

Fig. 2

after which numbers rose rapidly—presumably as the southern air from the west was encountered. Such a clear and potentially valuable correspondence between air-masses and their spore, etc., load is largely to be expected when we think in terms of regions of origin, and perhaps is not necessarily much confused by mixing or loss by sedimentation, etc., even during long and tortuous travels.

(6) Analysis of the paths of the air-masses in which the other flights were made seems less significant, and in any case Mr. McLeod warned that in these instances the lack of upper-wind data made their earlier movements doubtful. However, it seems that the second sortie was in northerly winds coming from arctic Canada, and probably of just that origin—which may well explain the lack of uredospores and gymnospermous pollen and the general paucity of material caught. The third sortie, however, is interesting in its seeming support of the implication of the previous paragraph that the load of particles, etc., carried by an air-mass depends more on its origin, or at least its history, than on its trajectory or actual position at any time: for whereas the early stages of this flight were made in air-masses coming from the north, as was the case in the second flight, and the results were similarly so nearly negative that the slides constituted a kind of control, the last stage coming in towards Yellowknife was in air of north-westerly origin, which appeared to have a trajectory not unlike that of the air-mass in which the first flight of all was made, and actually showed a more comparable spore load.

(7) It appears that although the smaller spores of crop pathogens are alone apt to be at all numerous, pollen grains and other spores of a wide variety of types and especially of anemophilous species carry quite well in the atmosphere, and certainly some can occur at high altitudes[7] and in remote regions not merely over land but also over the ocean[8]. All too little is yet known of the extent to which they may remain viable; but it has been determined that a range of pollens of by no means hardy types can give a high percentage of germination and produce strong seedlings even after the greater part of a year of storage[9], and that low temperatures and light-intensities and atmospheric pressure (but medium humidities) can favour pollen longevity[9,10]. In these and other circumstances, such as the almost perpetual windiness preventing particles from settling, it seems conceivable that the possibilities of long-range and hence 'absent-treatment' hybridization even among plants which do not practise the 'spring-flowering idea' may be greater in the Arctic than in some climatically more favourable regions where dense foliage, etc., impedes take-up and effective falling of 'pollen rain'—as well as where much of the atmospheric pollen is removed by precipitation—and may perhaps be one of the factors behind the tiresome 'plasticity' of many groups of arctic plants, including, particularly, the Gramineæ, Cyperaceæ, Juncaceæ, Salicaceæ, Cruciferæ, Rosaceæ, and Compositæ.

In conclusion, it should be re-emphasized that these suggestions are largely tentative, being based on too limited experience and too few data to allow sound generalization. It may even be objected that the small numbers of significant items observed on many of the slides are not beyond the possibilities of contamination; but the precautions taken, the advice of examining specialists, the working of controls, and the over-all picture now that it is possible to see it, all give confidence that even individual observations have value and probable validity. The above data are published with the approval of the Defense Research Board of Canada, which has generously supported the continuation of this work with an extra-mural grant in my name.

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THE JOULE MUSEUM, SALFORD

THE Joule Museum, which was opened on July 3 at Joule House, Salford, contains a permanent exhibition of apparatus and documents and is intended to be a comprehensive presentation, by original or replica, of J. P. Joule's major scientific work. The existence of this exhibition is due to the initiative of the British Society for the History of Science, which delegated the task of forming the Museum to Prof. L. Rosenfeld, University of Manchester; in this, Mr. J. A. Newth was a ubiquitous lieutenant.

The nucleus of the Museum is a collection of original apparatus and documents which had been acquired by the Manchester College of Technology—through the agency of Prof. W. W. Haldane Gee—after Joule's death, when his house and property at Sale were disposed of. They have since been preserved at the College of Technology, where they could not be properly exhibited for lack of space. This collection has now been completed by replicas from original apparatus preserved elsewhere, and the whole has been displayed in a room of a house at Salford in which Joule lived for some years, and which is now owned by Salford Corporation. A grant of money from the University of Manchester and the provision of this room in Joule House, arranged by Mr. A. J. Rivett, director of education for Salford, made it possible to display the collection to the best advantage.

The replicas of apparatus have been constructed by Mr. R. Bradford in the workshop of the Physics Department of the University of Manchester. Apparatus was lent for this purpose by the Science Museum, South Kensington, London, through the agency of Mr. J. Chaldecott, and by the Department of Natural Philosophy, University of Glasgow, with the co-operation of Prof. P. I. Dee. The documents comprise a large laboratory book, some notebooks, manuscripts and letters, which come from a variety of sources.

The exhibits are arranged in sections which follow each other chronologically. The early experiments sprang out of a desire to improve Sturgeon's electromagnetic engine, and to arrive at a quantitative estimate of its "duty" or efficiency. There are shown a number of toy-like models of electrical motors and cores of electromagnets of various constructions which were used to study their "lifting-power". This section recalls Joule's friendship for William Sturgeon,

whose encouragement may have determined the direction of these early experiments.

In the next period (1840–43) was performed a series of experiments concerned with the connexion between electricity and heat. A reconstruction of the simple apparatus which Joule used to measure the heat produced in a conductor by an electrical current is shown, together with a replica of the remarkable arrangement by which he confirmed his allegiance to the theory that heat is a mode of motion, and first established the equivalence between work and heat. A coil is mounted inside a cylindrical calorimeter (25 cm. × 10 cm.) and can be rotated between the poles of a fixed electromagnet. Joule was able to show that heat is actually generated in the coil by the induced current and that this heat is proportional to the mechanical work done in turning the apparatus. Direct voltaic currents were superimposed on those induced in the coil, and the measurements of the heat produced led to the conclusion that, in these experiments, mechanical work was converted into heat through the intermediary of electricity.

In 1844 Joule turned to a study of the heat changes accompanying the expansion and compression of gases; the original apparatus used in this series of experiments is exhibited in a complete state. Two large cylindrical copper vessels were connected through a needle valve ("the invention of Mr. Ash, of this town"). One of the cylinders was evacuated; the other could be filled to a pressure of 22 atmospheres by 300 strokes of a hand-pump. By immersing the whole arrangement in a calorimeter and opening the valve, Joule discovered that "no change of temperature occurs when air is allowed to expand in such a way as not to develop mechanical power". Unknown to him, this law had already been found in 1806 by Gay-Lussac; it played an essential part in the reasoning by which Robert Mayer deduced in his own way the mechanical equivalent of heat in 1842.

The next period (1845–49) was occupied with the famous friction experiments. Replicas are shown of the two paddle-wheel calorimeters, for the friction of water and mercury, and of that which contained two metal plates in close contact and which was used to produce heat by the friction between solids. All these systems were activated by falling weights. Unhappily, the thermometers which were used in Joule's experiments and preserved by the Manchester Literary and Philosophical Society were destroyed in an air-raid; there remain but a few relevant documents, including the invoice from the French firm which supplied some of them.

One of the most important events of Joule's life was his meeting with William Thomson (later Lord Kelvin) at the British Association meeting of 1847. This was the beginning of a long period of fruitful co-operation and mutual stimulus. For Thomson, it was the starting-point of the investigations which led him, shortly after Clausius, to the recognition of the two fundamental laws of thermodynamics.

In exploring the consequences of these laws, Thomson pointed out that a gas would be cooled by allowing it to expand into a region of lower pressure, and in 1852 Joule and Thomson started a long series of experiments which confirmed this deduction. There are exhibited the wooden containers for the porous plugs which were used to separate the regions at high and low pressure, and the few other surviving parts of the apparatus.

Joule's last experimental work, in 1878, was a new accurate determination, by the paddle-wheel friction method, of the mechanical equivalent of heat. It was undertaken at the request of the British Association Committee on Standards of Electrical Resistance, in order to clear up a discrepancy between the previous friction value and that derived from the heating effect of a current passing through a resistance which had been compared with the standard issued by the Committee. A replica of the calorimeter used by Joule for this experiment is exhibited, together with Joule's British Association standard resistance. The resulting value for the equivalent was almost identical with that obtained thirty years before by the same method.

The last section of the exhibition is devoted partly to some instruments which were probably permanent features of Joule's laboratory, and partly to a selection from a number of odd pieces of apparatus used in minor investigations of a varied character—especially in a careful study of the mechanism of steam condensation. Joule's precision instruments were made by John B. Dancer, an optician and scientific instrument maker of great reputation who carried on business in Cross Street, Manchester, from 1841, and was himself a distinguished amateur of science.

Documents and letters of special interest are displayed at appropriate places in the various sections, and also in separate show-cases. On the walls hang a portrait of William Sturgeon and two portraits of Joule himself. One of them is a photograph of the portrait by Collier owned by the Royal Society, and exhibited by permission of the Council of the Society. The other is a large oil-painting on loan from the Manchester Literary and Philosophical Society, which replaces the original portrait by Patten destroyed in the air-raid of 1940.

While the scientific aspect of Joule's investigations can be reconstructed in a fairly complete way, it is a matter of regret that so few documents have been preserved which could throw light on his personality. Why did he devote himself to scientific pursuits when so much else might have been expected of a rich brewer's son? Who taught him the rudiments of his craft, and inspired his father to build him a laboratory? Whence came that almost arrogant courage which relied on the visual subdivision of a thermometer interval into twenty parts for the enunciation of a new law of Nature? What gave him such an ascetic devotion to a principle when his city was crying out for technical improvements and inventions?

It would be interesting to know more of his relations with people like Dalton and William Sturgeon, of his wife and family. There is some evidence that he was handicapped by a physical deformity that may have made him a recluse. It is certainly true that the last years of his life were given up to the infirmity of old age. But it is strange that so much can have been forgotten about a man whose life-span overlapped that of our fathers.

The Joule Museum is open to the public, on application to the offices of the Child Guidance Clinic on the ground floor of Joule House, 49 The Crescent, Salford; parties or individual visitors who would like to be accompanied by a member of the staff of the Physics Department of the University of Manchester should make arrangements in advance with Prof. L. Rosenfeld at the Department.

THE CHEMICAL RESEARCH LABORATORY, TEDDINGTON

THIS year 'open days' at the Chemical Research Laboratory, Teddington, were held during September 19–21, and many representatives of industrial firms, universities, government departments and the Press took the opportunity to view the work in progress. It may be mentioned that a new laboratory is under construction, although it was not open to inspection this year; this is designed for chemical work with radioactive materials and will be ready for occupation during 1952. In addition, plans for a new microbiological laboratory have been drawn up and construction will begin this year. A useful addition to the facilities of the Laboratory is a new glass-working hut, equipped with lathe and other apparatus for high-grade work. Researches were illustrated by many exhibits, and this article is confined to some indication of the general programme of the six research units, and a more detailed description of some of the newer exhibits.

The Corrosion of Metals Group is concerned with corrosion and its prevention in immersed, atmospheric and underground conditions. This includes work on the development of accelerated corrosion tests, the application of inhibitive methods, and new work on boiler-tube corrosion. The Group has a special interest in the surface films on metals, and the chief object of new work on the oxidation of metals below 250° C. is to provide experimental data that may be used to test or formulate theories on the oxidation of metals in this temperature range. In these experiments particular attention has to be paid to the physical and chemical nature of the metal surface employed. The properties of the electrolytically polished surfaces of polycrystalline copper sheet of high purity have been examined by the optical microscope, by electron diffraction and by an electrometric method. The last-named enables the very thin oxide films (~ 25 A.), formed during surface preparation, to be measured and provides a ready means of detecting the presence of certain undesirable contaminating layers on the surface, if they are present. Kinetic studies on the oxidation of these samples at pressures in the range 10^{-1}–10^{-4} mm. of mercury, using a manometric technique, have revealed that the oxidation-rate is markedly dependent on the oxygen pressure. This variation is of considerable theoretical interest, and a full-scale investigation using a micro-gravimetric procedure is now in progress.

Interesting work on the electrode-potential behaviour of metal specimens in anaerobic culture media inoculated with *Desulphovibrio desulphuricans* has been commenced. In particular, the polarization characteristics of the metals in conditions suitable for the vigorous proliferation of sulphate-reducing bacteria are being studied.

The Radiochemical Group is mainly engaged on a programme of work for the Ministry of Supply on the analysis of radioactive minerals and ores, and the concentration of metals from low-grade sources. A recent advance is the application of ion-exchange resins in separation processes. If a solution containing a mixture of metals is passed through a column of cation-exchange resin, the metals are absorbed in amounts depending on their concentration in the solution and their affinity for the particular resin used. Not only can a dilute solution be concentrated and freed from unwanted anions, but also, by choosing the correct conditions, the process can be selective for a particular metal. An exhibit demonstrated how a multi-column adsorption system can be employed for this purpose. Work on the separation of metals by paper-strip chromatography or cellulose columns has been continued, and a new separation exhibit was that of platinum and palladium from iridium.

The Inorganic Group has been working on a variety of topics, such as the extraction of gallium and germanium from flue dust, and the conversion of rock phosphate into fertilizer by methods designed to reduce the consumption of sulphuric acid. The Group is also responsible for the microanalytical and spectrographic analytical work required by the Laboratory.

Germanium continues to find an increasing use for micro-wave rectification and as a substitute for the triode valve. Considerable difficulty has been experienced in producing material of the necessary high degree of purity, one of the most troublesome impurities being arsenic. The problem has been studied using radioactive tracer methods, and a method of purification has been developed which yields germanium dioxide containing less than 0·01 p.p.m. of arsenic, and which is well suited to commercial application. Germanium metal derived from this oxide has a satisfactory electrical performance. The work is being continued with the view of the elimination of other elements, notably boron, which may be present in minute traces and may affect the electrical properties of the metal.

A feature of the work of the Organic Group is the preparation of organic compounds in a high state of purity and the determination of precise physico-chemical data in collaboration with the National Physical Laboratory; this includes the lower hydrocarbons used for the calibration of mass spectrometers, cyclic and heterocyclic compounds, and long-chain fatty acids. The Laboratory is now equipped with low-temperature distillation units (including a Podbielniak 'Hyd-Robot') for the preparation of pure low-boiling hydrocarbons, and spinning-band fractionating columns for the distillation of the esters of long-chain acids.

Part of the work in collaboration with the National Physical Laboratory is the determination of the end-products of combustion of nitrogen-containing compounds in the bomb calorimeter. An oxygen-purifying train for the preparation of pure oxygen, and apparatus for analyses of the bomb contents, were on view. Studies of the synthesis of compounds containing labelled carbon have been continued, and some new syntheses, including ring-labelled aromatic compounds, were exhibited. γ-Resorcylic acid has been prepared for clinical tests for the Medical Research Council.

A discovery of great potential importance in connexion with the determination of molecular weights of polymers by osmotic measurements has been made in the High Polymers Section. It has been found that polyvinyl alcohol may be used for preparing improved semi-permeable membranes which possess the advantages of permitting very rapid passage of the common polymer solvents and yet enable rapid and accurate measurements to be made of the number-average molecular weights of polymers of considerably lower degrees of polymerization than heretofore. Furthermore, osmometers of very simple design may be used.

The shortage of sulphur has stimulated inquiry into new sources. The possibility of using micro-organisms for sulphur production from indigenous sulphates is being examined by the Microbiology Section. In June 1950 two members of the Section examined some sulphur-producing lakes near El Agheila in the Cyrenaican desert; they found that the formation of sulphur was due to the combined action of sulphate-reducing and photosynthetic sulphide-oxidizing bacteria. Details of the expedition, illustrated by maps and photographs together with many of the samples actually obtained, were exhibited. Of special interest was a demonstration of the production of sulphur by the symbiotic action of pure cultures of the two types of organisms isolated from the Cyrenaican lakes in a medium containing sulphate as the sole sulphur source.

Included in the Microbiology Section is the National Collection of Industrial Bacteria. Although still in its formative stage, the Collection now maintains more than five hundred strains. Its usefulness is indicated by the increasing world-wide demand for its cultures; last year, more than four hundred strains were supplied to [illegible] countries. The multifarious activities involved in maintaining cultures were demonstrated, for example, the technique of vacuum freeze-drying; diagnostic bacteriological and biochemical tests used for identification and classification; card index system; package and storage. The use of specific types of bacteria for the assay of antibiotics was illustrated.

NEWS and VIEWS

National Science Foundation, Washington: Dr. Paul E. Klopsteg

Prof. Paul E. Klopsteg, professor of applied science and director of research of the Northwestern Institute of Technology, has been appointed assistant director of the National Science Foundation for the Division of Physical, Mathematical and Engineering Sciences. Dr. Klopsteg, formerly president of the Central Scientific Company, has long been associated with the administration of research. During the Second World War he served with the Office of Scientific Research and Development as chief of Division 17, Physics and Special Devices, of the National Defense Research Committee, which developed important equipment and devices for war-time use. Notable among the Division 17 developments were the three 4,000,000-volt X-ray machines built by the University of Illinois under contract with the Office of Scientific Research and Development, and the high-voltage Van de Graaff machine developed under contract with the Massachusetts Institute of Technology for the X-ray inspection of heavy military equipment. Later in the War, Dr. Klopsteg was appointed assistant chief of the Office of Field Service, which organized the supply of scientific consultants to the various theatres of war; in this capacity he was made chief of the Research Division, General Headquarters, Southwest Pacific Area in Australia and New Guinea in 1944. Dr. Klopsteg was awarded the Medal for Merit with Presidential Citation for his war-time work. Continuing his association with Federal research activities since 1945, he has been a member and chairman of the board of governors of the Argonne National Laboratory, operated by the University of Chicago under contract to the U.S. Atomic Energy Commission. Dr. Klopsteg has been director and treasurer of the American Association of Physics Teachers and chairman of the executive committee of the American Institute of Physics. In his leisure he has studied archery, and he is an honorary member and former chairman of the board of governors of the National Archery Association in the United States.

George Francis FitzGerald Centenary

The Royal Dublin Society will hold a special scientific meeting at 4 p.m. on October 30 to mark the centenary of the birth of George Francis FitzGerald. FitzGerald played a prominent part in many branches of theoretical physics during the last two decades of the nineteenth century, and was the first to show that the generation of electromagnetic waves by oscillating electric circuits was theoretically possible, a prediction verified a few years later by Hertz. He is probably best remembered to-day as one of the authors of the FitzGerald–Lorentz contraction hypothesis, a forerunner of the theory of relativity, which he and Lorentz put forward independently to explain the null result of the Michelson–Morley experiment. The meeting will accordingly be devoted chiefly to the presentation of communications dealing with some modern views on relativity theory. These will include the following papers: Dr. H. E. Ives, "The FitzGerald Contraction"; Prof. W. H. McCrea, "The FitzGerald-Lorentz Contraction—some Paradoxes and their Resolution"; Dr. G. J. Whitrow, "The FitzGerald-Lorentz Contraction Phenomenon and Theories of the Relativity of Galilean Frames"; Prof. J. L. Synge, "Effects of Acceleration in the Michelson-Morley Experiment"; and Prof. F. E. Hackett, "FitzGerald as revealed by his Letters to Heaviside". It is hoped that in addition Dr. E. H. Alton, provost of Trinity College, Dublin, and Prof. H. H. Dixon will contribute personal reminiscences of FitzGerald.

Training of a Technologist

In his Redwood Lecture "The Training of a Technologist", delivered to the Institute of Petroleum on October 3, Prof. F. H. Garner, professor of chemical engineering in the University of Birmingham, emphasized the importance of the applied scientist possessing, besides his technical knowledge, some understanding of the human mind, personal qualities of leadership and the knowledge of how to handle men, which can be gained only by personal contact and not through books. Prof. Garner did not agree that education should be based solely on the humanities, but he pointed out that the defects of such an education, particularly when it includes no training in science nor any scientific background, is due at least in part to the decay of the religious element and the Christian ideals or philosophy which, until the Edwardian era, had a more marked influence than the classical philosophies. There has been a violent change with our traditions, and it is always desirable that in traditions the rate of change should be slow. This is one of the real reasons why the educated part of the community is proving unfitted to deal with the problems of to-day;

but it is important that the technologist, who would have to deal with human problems throughout his career, should also be able to bring a balanced outlook to bear on the questions of human relations or of administration with which he might be confronted. Prof. Garner maintained that properly taught engineering represents a complete discipline and a philosophy in the sense of the ability to see a particular field of knowledge in all its human relations. He protested strongly against the tendency to compartmentalize knowledge and stressed the opportunities which are offered by borderland subjects like physical chemistry. With an educational training in the humanities, science, both pure and applied, can be taught so as to enable one to be clear, logical and objective, able to interest people, to assess evidence, form reasoned judgments and explain them clearly to others. It is Prof. Garner's opinion that contact with industry in teaching applied science is essential and can with advantage be improved, especially where the training is being given in industry.

Scientific and Technical Man-power in the United States

THE feature of No. 4 of *News Report*, issued by the National Academy of Sciences—National Research Council (Washington, D.C.; July–August 1951) is an article by Dr. M. H. Trytten, director of the Office of Scientific Personnel, on the "Manpower Shortage in the United States". Analysing the intake available to maintain over a long period the projected military strength of 3·5 million men, Dr. Trytten points out that this figure has been achieved because of the existence of several groups—the pool of males without military service between the ages of eighteen and twenty six, personnel in military reserve status, and the career personnel. There are probably 750,000 career men now in the Armed Services; but to maintain a military strength of 3·5 million will require more than two years of service from all able-bodied youths, even without exemptions. With exemptions the average length of service of all youths not exempted must increase. Without exemptions the whole technology of the nation is in jeopardy. Meanwhile, the demand for technological personnel has mounted, and this summer more than twice as many scientific workers and engineers as were available could have been absorbed in research, production or teaching. It is also estimated that the output of scientific workers and engineers, even without the impact of the draft, is likely to decrease until at least 1955. In view of this situation the Director of Defence Mobilization has established a policy committee to make recommendations on all issues of policy affecting the handling of problems in utilizing scientific and technical personnel. The National Academy of Sciences appointed early in 1951 a committee to examine the situation; and it is believed that the recommendations of this committee, which were adopted by the Academy in April and included the establishment of a National Scientific Personnel Board in the Office of Defense Mobilization to study intensively all such problems, will receive careful consideration when the problem of specialized manpower is discussed.

The Scientific Outlook in 1851 and in 1951

THIS is the title of a Discourse delivered at the Royal Institution by Prof. H. Dingle last March, and reproduced as an article in the August issue of the *British Journal for the Philosophy of Science*. Prominence has been given at the recent Festival Exhibitions to the difference that science has made in practical affairs during the past hundred years. It is most fitting that there should be a permanent record of another aspect of scientific development, namely, the change in scientific outlook. In the first part of the article, Prof. Dingle emphasizes the basic assumption of the scientific men of 1851 that there was lying before them a world of material objects, moving about in space and time with, as Whewell maintains, a "*substance*, which stands beneath the apparent qualities and supports them". The reality of the substance was held to be its weight. Yet, as Prof. Dingle points out, it was the roundness and colour of Neptune, not its intrinsic property of weight, which was taken to be the guarantee of existence. The revolution that came in the twentieth century was simply the overthrow of that false notion of what science was and is; science itself has pursued the same undeviating course from Galileo through Newton and Einstein to our own time. The implications of the special theory of relativity are incompatible with any form of materialism. Prof. Dingle continues his argument to show the fallacy of the so-called philosophy of dialectical materialism. His treatment is both convincing and stimulating; the nineteenth-century disputes between science and religion are shown in perspective, and of possible further conflict he believes that the highest wisdom lies in recognizing both the relations between experiences and the very different values of the things related: "The discarding of old prejudice and the cultivation of a new outlook are not matters that can be completed in a moment". Prof. Dingle's article is a valuable contribution toward establishing this new outlook in place of dogmatic assertions of a hundred years ago.

Errors in the Carbon-14 Method of Archæological Dating

NEW lines of investigation are almost always welcomed with enthusiasm, more particularly when they involve disciplines in another subject than the one upon which they may throw light. It is a long time ago now since prehistorians were told all about their subject by human anatomists, and more recently the help of pollen analysis and the fluorine test has been readily accepted. Fortunately, the last two have been introduced to prehistorians by true scientific workers who have not failed to impress upon them the limitations and dangers of the new disciplines. Finally, there has appeared upon the scene the method of accurately dating prehistoric objects in years by analysing the percentage of the rare carbon-14 isotope present in material relative to the ordinary carbon-12. There is no doubt that this is a very valuable new method of study, and it has been taken up enthusiastically in the United States. Equally obviously, there are numberless factors, not perhaps all yet clearly understood, which may completely vitiate the results. A recent short article, only two pages in length, entitled "Radiocarbon Datability of Peat Marl, Caliche, and Archæological Materials", by H. H. Bartlett (*Science*, **114**, No. 2951; July 20, 1951), describes just one such example. The author points out that when samples for study are taken from a site where alternating layers of marl and peat occur, the readings may be entirely erroneous owing to the presence of an unknown quantity of 'dead' carbon-12 derived from geologically ancient calcium carbonate;

this may dilute the equilibrated mixture of carbon-12 and carbon-14. Warnings like this do not, of course, invalidate the carbon-14 method of study; but they do impress upon us that we must be slow in accepting as infallible new methods of study until all the possible factors and circumstances bearing upon them have been considered and studied.

Forestry and Conservation in South Africa

In a recent issue of the *Journal of the South African Forestry Association* (Pretoria; No. 20, April 1951), under "Editorial Notes and Comments", there is a strong note on forestry and conservation which is equally applicable to a good many other parts of the world. The note points out that the South African forester and his activities are often condemned by his compatriots when in other countries they would be regarded as constructive and conservational. At one time or another, the forester has been accused of causing erosion, desiccation, destruction of the indigenous vegetation, of championing the exotic against the indigenous tree, of despoiling the beauty of the countryside with artificial plantations (some of these complaints have been heard in Great Britain) and so forth. The note continues to the effect that, so far as South Africa is concerned, if these accusations could be substantiated they would apply with a far greater force to the agricultural operations carried out in that somewhat arid land during the past half-century; this view is supported and expressed by the editor of the *Journal of the Botanical Society of South Africa* (Part 35; 1949) in the following words. "The effect of afforestation upon water supplies has been ably analysed and discussed by Dr. C. L. Wicht (Department of Forestry Bulletin No. 33; 1949). Much is still uncertain and awaits the results of experiments which are in progress. But it is clear, incidentally, that the relative importance of this subject has been much exaggerated when compared with the obvious flagrant and destructive results of much current agricultural and pastoral practice over great areas in the Union. The work of the Forest Department is mainly constructive and conservational; our farming methods are largely exploitational."

Artificial Insemination of Birds

The first Supplement Number of *The Onderstepoort Journal of Veterinary Research* (1951. Gov. Printer, Pretoria. 5*s*., overseas postage 1*s*.) is devoted to a valuable paper, 212 pages long, by G. C. van Drimmelen, on artificial insemination of birds by the intraperitoneal route. The paper discusses the historical background of this subject, its literature, and the author's own extensive work. There are three appendixes, one on the intraperitoneal method of insemination, one on the fowl cocks and the semen samples used, and the third on the post-mortem examination of the genitalia of hens. The bibliography, 11½ pages long, will be useful to all workers on this subject.

University of Leeds

It has been announced from the University of Leeds that the title of emeritus professor has been conferred upon Prof. R. Whiddington on his retirement from the Cavendish chair of physics. Dr. J. G. Wilson, senior lecturer in physics in the University of Manchester, has been appointed to a chair of physics at Leeds as from June 24, 1952.

The following lecturers (in the subjects and/or departments as shown) have been appointed: R. L. Holmes (anatomy), G. A. Mogey (pharmacology), K. G. Towers (veterinary officer and lecturer in veterinary hygiene in the Department of Agriculture), Dr. F. K. Sutcliffe (research lecturer in the Department of Colour Chemistry and Dyeing), and Dr. R. Reed (Department of Leather Industries).

The Night Sky in November

Full moon occurs on Nov. 13d. 15h. 52m., U.T., and new moon on Nov. 29d. 01h. 00m. The following conjunctions with the moon take place: Nov. 10d., 06h., Jupiter 4° S.; Nov. 24d. 11h., Mars 4° N.; Nov. 25d. 10h., Saturn 6° N.; Nov. 25d. 18h., Venus 6° N.; Nov. 30d. 14h., Mercury 2° N. In addition to these conjunctions with the moon, Venus is in conjunction with Saturn on Nov. 21d. 10h., Venus being 0·6° S. Mercury sets too soon after the sun during the greater portion of the month for favourable observation; the planet attains its greatest elongation east on November 28, and on November 30 sets nearly an hour after sunset, when it can be seen in the western sky for a short time. Venus, a morning star, rises at about 2h. 40m. up to the middle of the month, and at 3h. 20m. at the end of the month, with stellar magnitude −4 and the visible portion of the illuminated disk varying between 0·42 and 0·58. Mars is a morning star, stellar magnitude 1·7, rising a little before 2h. throughout November. Jupiter is visible throughout the night, setting at 3h. 45m. on November 1 and at 1h. 45m. on November 30, stellar magnitude −2·3; the planet is stationary on November 30, after which it has an eastward movement in the constellation Pisces. Saturn is a morning star, rising at 4h. 10m., 3h. 20m., and 2h. 30m. on November 1, 15 and 30, respectively, and is easily recognized a little south of γ Virginis in the early part of the month. Only one star brighter than magnitude 6 is occulted in November; on Nov. 10d. 17h. 40·6m., 8 Piscium disappears (observable at Greenwich). The Leonid meteors, towards the middle of the month, which have been very feeble for many years, will be difficult to observe owing to moonlight.

Announcements

H.R.H. the Duke of Edinburgh has been elected an honorary fellow of the Institute of Navigation.

The Royal Society of New Zealand has awarded the T. K. Sidey Medal and Prize for 1951 to Prof. V. A. Bailey, professor of experimental physics in the University of Sydney, for "research in Radiation as bearing on Human Welfare". This Award is the most important made by the Royal Society of New Zealand by virtue of its international character. It was established to commemorate the passing by the New Zealand Parliament of the Summer Time Act, 1927, and was raised by shilling subscriptions, thus making possible a tribute by all to the value of the measure to human welfare.

The following appointments have been made in the University of Sheffield: Dr. T. H. Barton, lecturer in electrical engineering; Drs. W. H. Evans, H. C. Grimshaw, E. M. Guenault, W. C. F. Shepherd and F. V. Tideswell, to be honorary lecturers in mining. The John Stokes Research Fellowship has been awarded to Mr. H. L. Kornberg, who will work in the Department of Biochemistry; a Knoop Research Fellowship in Economics has been awarded to Mr. D. C. Corner.

A FAST CONTINUOUS ELECTRODIALYSER FOR HYDROPHILIC COLLOIDS, AND A FAST CONTINUOUS ELECTRODECANTER FOR HYDROPHOBIC COLLOIDS

By Prof. A. J. RUTGERS and R. SWYNGEDOUW
Laboratory for Physical Chemistry, University, Ghent

DURING the past three years, Dr. G. Jacobs[1] has carried out in our Laboratory researches on centrifugation potentials in colloidal solutions of arsenious sulphide; this sol can be prepared by passing a stream of hydrogen sulphide through a solution of arsenious hydroxide; no foreign electrolyte is produced, hence no dialysis is required. If we want, however, to extend these researches to other colloidal solutions, the difficulty arises that these sols cannot be prepared from base plus acid; they must often be prepared by a reaction like:

$$AgNO_3 + KI = AgI + KNO_3.$$

Thus an indifferent electrolyte (KNO_3) is formed, and dialysis is required in order to remove it. This takes time, especially if a considerable quantity of a highly concentrated sol is required. We have therefore constructed a fast continuous electrodialyser. This apparatus (Fig. 1) fulfilled expectations when used for the dialysis of hydrophilic colloids; if, however, hydrophobic colloids were handled in this apparatus, immediate electrodecantation occurred. We then decided to make a virtue of necessity, and to effect a separation of the hydrophobic sol into a dilute part and a concentrated part by electrodecantation; for this purpose the apparatus had to be duplicated in the direction of its longitudinal axis (Fig. 2).

The apparatus of Fig. 1 can be considered as a further development of a dialyser devised by Brinkman[2]; this dialyser consisted essentially of a glass tube around which a sausage skin fits. This system is placed in distilled water; dialysis takes place in the space between the glass tube and the sausage skin. We developed this apparatus into an electrodialyser (Fig. 1). Around the central glass tube we put first a platinum gauze, then a sausage skin, then a somewhat longer sausage skin; this system was placed inside a glass tube, which carried on its inner wall another platinum gauze. In this way we obtained an inner washing space, a space for the sol, and an outer washing space; feed and outlet pipes for each of these compartments could be fitted inside the central tube; they pierce its walls in the appropriate places. Molten paraffin is poured inside the central tube; after solidification it holds the numerous glass tubes firmly inside the central tube.

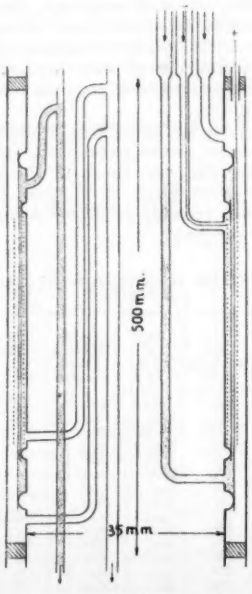

Fig. 1. Fast continuous electrodialyser for hydrophilic colloids

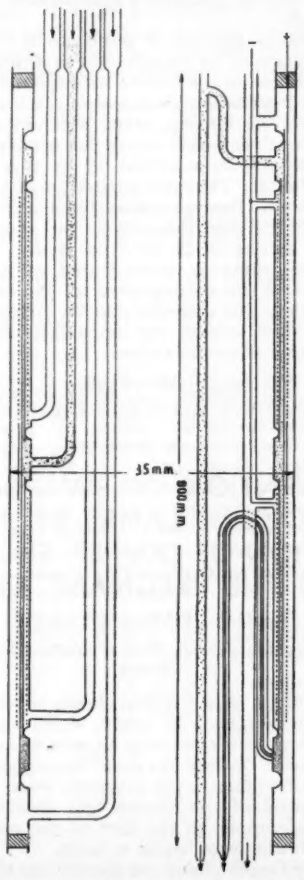

Fig. 2. Fast continuous electrodecanter for hydrophobic colloids

During dialysis, the counter-current principle is used. The sol enters at the bottom and leaves at the top; the washing water flows in the opposite direction. Hydrostatic pressure must be highest in the inner wash-chamber, medium in the sol-chamber, lowest in the outer wash-chamber. This can be obtained by giving a suitable shape to the outlet pipes.

With this apparatus (diameter of inner tube 38 mm., of outer tube 55 mm.; length of platinum gauzes 200 mm.), 200 cm.³ per hour of a hydrophilic sol could be freed from electrolyte (current density 3 m.amp./cm.²; current about 0·7 amp.; voltage 100).

There is no reason for expecting the new apparatus to be efficient in removing non-electrolytes, such as urea; this was confirmed by experiment. It is unfortunate, for a simple apparatus capable of removing urea with good efficiency would be of great medical value (artificial kidney).

If a hydrophobic sol, for example, a silver iodide sol, is introduced into the apparatus shown in Fig. 1, electrodecantation occurs, and the concentrated sol sinks to the bottom, where it mixes with the freshly introduced sol. If the apparatus is slightly changed, so that the sol can be introduced at the top, it sinks rapidly to the bottom, and appears not to be dialysed at all; moreover, the liquid leaving the apparatus at the top always contains a considerable amount of silver iodide.

We therefore decided to duplicate the apparatus in the direction of its longitudinal axis (Fig. 2); the sol is introduced in the middle, at a speed of 200 cm.³ per hour; decantation takes place; the concentrated sol sinks to the bottom, while a liquid containing only a little silver iodide leaves the apparatus at the top; if electrolyte is carried off by this liquid, so much the better. The concentrated sol at the bottom is taken from the apparatus by a siphon-shaped capillary of 0·4 mm. diameter (a tap should not be used); it carries off 20 cm.³ per hour; this sol is about seven times as concentrated as the original sol. A litre of this concentrated sol can be prepared in two days; this quantity can be further dialysed in a Pauli dialyser in one operation, in order to obtain it free from electrolyte. [May 8.

[1] Jacobs, G., *Versl. Kon. Vl. Akad. Wetensch.*, **7**, 4 (1915); **13** (in the press, 1951). Rutgers, A. J., *Nature*, **157**, 34 (1946).
[2] Brinkman, R., cf. W. J. Kolff, thesis, Groningen, p. 13 (1946).

PREVENTION OF SWAYBACK SYMPTOMS IN LAMBS BY ADMINISTRATION OF COPPER SULPHATE TO THE PREGNANT EWE

By Dr. GEORGE DUNLOP

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In a previous paper[1] it was shown that the occurrence of swayback in lambs, which was enzootic on a hundred farms covering an area of forty square miles in north Derbyshire, could be prevented by the provision of copper to the pregnant ewes. In a later paper[2] control of the disease was obtained by the addition of copper to the diet of the ewes twenty days before the ewes began to lamb.

Recently Cunningham[3] has shown that the development of ataxia may be averted by regular drenching of the lambs with copper sulphate twice a week from birth until they are four months old. Each dose administered to the lambs consisted of 35 mgm. $CuSO_4.5H_2O$ (approximately 9 mgm. copper) in 0·5 oz. water. Administration of the doses was carried out on Monday and Friday of every week after the first lamb was born.

Bennetts found in 1937 that the disease was prevented by supplying copper to the mother before lambing occurs. Administration of a single dose of copper sulphate to affected lambs did not prevent development of the symptoms. Bennetts and Beck[4] showed that the feeding of copper to affected lambs arrested the progress of the disease.

Preventive measures for the control of the disease as it occurs in the west of Scotland have been studied for a number of years. Each year during March and April, farmers have reported to this Department that symptoms of the disease have appeared among the lambs in their flocks shortly after the commencement of the lambing season. This is usually the first indication that numerous cases of the disease will occur among the lambs yet to be born from the ewes in the flock.

Some method of control was desirable by which the ewes in the flock still to lamb would produce normal lambs which later would remain free from symptoms of swayback.

In 1940 and 1941 experiments were begun for testing practicable preventive measures; but during these seasons on low-ground farms there was no incidence of swayback in the experimental flocks. In 1942, 10 ml. of copper sulphate solution containing 200 mgm. copper was administered to each ewe still to lamb on one farm carrying Cheviot ewes which had been mated with a Border Leicester ram. The treatment was given one week after lambing had commenced in the flock, when a high percentage of the lambs already born had developed swayback. The incidence during previous years had also been appreciable. Following treatment of the pregnant ewes, no further cases of swayback occurred.

Similar results were obtained in another flock during the following year, while the original flock, in which the pregnant ewes were treated immediately before lambing commenced, showed no cases of swayback in the lambs.

The full results are presented in the accompanying table. This also shows experiences in other flocks subsequent to 1943. In these all the pregnant ewes after dosing gave birth to normal lambs. Ewes which were not treated produced a high percentage of abnormal progeny.

Treatment of Flocks susceptible to Swayback with Copper Sulphate

Flock	Year	No. lambing ewes	Date of treatment	Date lambing commenced	Per cent swayback during lambing in 1st wk.	2nd wk.	3rd wk.	4th wk.
A	1941	360	None	Mar. 14	13	8	14	17
A	1942	360	Mar. 20	Mar. 14	28	0	0	0
B	1942	84	None	Mar. 14	21	27	8	19
A	1943	360	Mar. 13	Mar. 14	0	0	0	0
B	1943	160	Mar. 20	Mar. 15	17	0	0	0
B	1944	160	Mar. 10	Mar. 14	0	0	0	0
C	1946	200	Mar. 16	Mar. 9	27	0	0	0
C	1947	200	Mar. 3	Mar. 9	0	0	0	0
D	1947	350	Mar. 15	Mar. 8	18	0	0	0
E	1947	320	Mar. 20	Mar. 15	17	0	0	0
F	1947	100	Mar. 17	Mar. 11	33	0	0	0
D	1948	350	Mar. 6	Mar. 8	0	0	0	0
E	1948	320	Mar. 8	Mar. 11	0	0	0	0
F	1948	100	Mar. 1	Mar. 11	0	0	0	0

In the west of Scotland it is now common practice to treat all ewes which may produce swayback progeny with copper at udder locking (within one week of lambing) or immediately swayback is observed in the lamb crop. One gram of copper sulphate dissolved in 30 ml. water is administered to each ewe.

No cases have been reported of the occurrence of swayback progeny in more than four thousand susceptible ewes treated in this way.

The administration of copper to the ewes immediately before lambing appears to provide complete control of swayback in the lamb crop on susceptible grazings.

[1] Dunlop, G., and Wells, H. E., *Vet. Rec.*, **50**, 1175 (1938).
[2] Dunlop, G., Innes, J. R. M., Shearer, G. D., and Wells, H. E., *J. Comp. Path. and Therap.*, **52**, 259 (1939).
[3] Cunningham, I. J., *N.Z. J. Sci. and Tech.*, **30**, 42 (1949).
[4] Bennetts, H. W., and Beck, A. B., Commonwealth Austral. Counc. Sci. Indust. Res. Bull., **147** (1942).

THE *IN VITRO* FORMATION AND DISPOSAL OF CARBON MONOXIDE IN BLOOD

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CARBON monoxide is constantly exhaled in human respiration, even when every possible external source of carbon monoxide is excluded[1]. It has also been shown that if blood is incubated at 38° C. for 10–24 hr., there is a constant increase of a factor which is determined as carbon monoxide. This increase is especially pronounced after hæmolysis[1,d].

This latter observation has now been confirmed and amplified in a further series of experiments (Table 1). In these investigations, the carboxy-hæmoglobin concentration was determined by Horvath and Roughton's method[2], and also by the method described by Siösteen and Sjöstrand[3]. Both methods gave the same results within the respective experimental errors for the concentrations involved (0·1 per cent and 7 per cent carboxy-hæmoglobin).

Table 1. Increase in Concentration of Carboxy-hæmoglobin in Hæmolysed Blood after Incubation at 38° C. for 20 hr.

Method	Species	No. of separate exp.	Per cent carboxy-hæmoglobin before incubation (I)	Per cent carboxy-hæmoglobin after incubation (II)	$\frac{II-I}{I} \times 100$
Horvath and Roughton	Man	12	0·44	0·75	75
	Cow	6	0·50	0·97	94
Siösteen and Sjöstrand	Man	12	0·45	0·66	47
	Cow	10	0·51	1·05	100
	Pig	2	0·34	0·74	118

Therefore, it is possible to draw the following conclusions about the factor under investigation. (1) It is chemically combined with hæmoglobin. (2) It is liberated on oxidation of hæmoglobin to methæmoglobin. (3) It is oxidized at room temperature in the presence of hopcalite. (4) The heat liberated on oxidation corresponds to the heat of combustion of carbon monoxide. It has also been found that: (5) the factor is absorbed by solutions containing copper sulphate and cuprous chloride; and (6) it reduces $H_3[Si(Mo_3O_7)]$ in the presence of palladium chloride, according to Shepherd[4].

Carbon monoxide is the only substance known to have this combination of properties.

If the *p*H of the blood is changed before incubation, the formation of carbon monoxide is accelerated (Table 2). This effect is especially pronounced at *p*H 4–6 and *p*H 9–11. At more extreme *p*H's, however, the formation of carbon monoxide is inhibited.

Table 2. Increase in Concentration of Carboxy-hæmoglobin in Blood, hæmolysed by Addition of Distilled Water at Different *p*H Values after Incubation at 38° C. for 20 hr.*

Method	Species	Per cent carboxy-hæmoglobin before incubation	Per cent carboxy-hæmoglobin after incubation: *p*H 4–6	*p*H 7·4	*p*H 9–11
Siösteen and Sjöstrand	Cow	0·69		1·35	2·60
	Cow		2·10	0·98	1·35
	Pig	0·84	2·20	1·10	1·70
	Pig	1·27	3·98	1·39	2·24
	Pig	1·00	3·79	2·20	3·95

* Changes of *p*H were obtained by using weak hydrochloric acid and sodium hydroxide solutions without the addition of buffers.

As may be seen from Table 3, the formation of carbon monoxide at *p*H 7·4 is greatly increased in the presence of 1/200 sodium azide, and the values are similar to those obtained after changing the *p*H of the blood. Thus, the comparative inhibition at *p*H 7·4 appears to be reversed by sodium azide.

Table 3. Increase in Concentration of Carboxy-hæmoglobin in Blood after Addition of Sodium Azide, 1 : 200, and Incubation at 38° C. for 20 hr.

Method	Species	No. of separate exp.	Per cent carboxy-hæmoglobin after incubation: before incubation	without sod. azide	with sod. azide
Horvath and Roughton	Man	9	0·58	0·83	1·95
Siösteen and Sjöstrand	Man	12	0·45	0·66	1·74
	Cow	2	0·85	1·20	5·20

The effect of different tensions of carbon monoxide on the formation of carbon monoxide in blood was investigated by adding carbon monoxide to the blood before incubation, to produce 5–60 per cent carboxy-hæmoglobin. In these experiments a significant decrease of the concentration of carboxy-hæmoglobin was observed in nearly every case after incubation (Table 4). Table 5 shows, however, that in the presence of sodium azide there is an increase in carbon monoxide formation, even with increased tensions of carbon monoxide.

Table 4. Decrease in Concentration of Carboxy-hæmoglobin after Incubation at 38° C. for 20 hr. with Increased Carbon Monoxide Tension

Method	Species	No. of separate exp.	Per cent carboxy-hæmoglobin before incubation	after incubation
Horvath and Roughton	Man	11	12·05	10·91
Siösteen and Sjöstrand	Man	9	10·55	9·74
	Pig	4	39·2	35·0

Table 5. Change in Concentration of Carboxy-hæmoglobin in Blood after Incubation at 38° C. for 20 hr. with Increased Carbon Monoxide Tension, with and without Addition of Sodium Azide (1 : 200)

Method	Species	No. of separate exp.	Per cent carboxy-hæmoglobin before incubation	Per cent carboxy-hæmoglobin after incubation: without sod. azide	Per cent carboxy-hæmoglobin after incubation: with sod. azide
Horvath and Roughton	Man	8	12·50	11·46	13·84
Siösteen and Sjöstrand	Man	6	11·06	10·40	12·16

These observations seem to indicate that carbon monoxide may be both formed in and removed from the blood. If the blood is incubated at 38° C., an equilibrium seems to be reached between these antagonistic reactions. The rate of disposal of carbon monoxide is determined by its tension, and has its optimum value at approximately *p*H 7. In normal life the equilibrium may be affected by the expiration of carbon monoxide, if the concentration in the inspired air is lower than that of the alveolar air, as is usually the case with ordinary atmospheric air. It has also been shown that the reaction is shifted to give increased carbon monoxide formation during physical exertion and on breathing 10 per cent oxygen in nitrogen[5].

The results of these investigations appear to provide an explanation of the endogenous formation of carbon monoxide, and also of the observations made by Fenn and Cobb[6], Clark, Stannard and Fenn[7], and Clark[8], that carbon monoxide is oxidized in isolated muscle preparations and in the intact animal. They may also explain the well-known fact that the carbon monoxide capacity of blood is slightly greater than the oxygen capacity.

A more detailed account of these investigations will be published in *Acta Physiologica Scandinavica*.

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SOCIETY FOR APPLIED BACTERIOLOGY

ANNUAL GENERAL MEETING

THE annual general meeting and conference of the Society for Applied Bacteriology was held in Marischal College, Aberdeen, during July 3–6. Approximately sixty-five members and visitors attended one or more of the four paper-reading sessions. At the meeting the resignation of the secretary, D. A. McKenzie, was announced and G. Sykes, of the Microbiology Division of Messrs. Boots, Nottingham, was appointed to succeed him. During the conference visiting parties were received at the Rowett Research Institute, the Macaulay Research Institute and the Torry Fisheries Research Station. Seventeen original papers and four demonstrations were presented at the four paper-reading sessions.

Miss M. J. Masson (Rowett Research Institute) described the microscopical methods used in a study of the gut of the sheep. The need for the use of direct microscopy as a preliminary to, and check upon, pure cultural and biochemical work on microbial populations was emphasized. Qualitative and quantitative changes in the microscopical appearance of contents from nine regions of the gut of a sheep fed with hay and a concentrate mixture and from the rumen of sheep fed with different diets were detailed. The isolation of *Clostridium butyricum* and lactobacilli from the rumen of a sheep fed with large quantities of flaked maize and small quantities of hay, and a Gram-positive streptococcus which liquefied gelatin, clotted milk, and later digested the clot, grew on McConkey's medium and survived 60° C. for 30 min., from the rumen of a sheep fed up to 300 gm. daily of casein, was reported.

Two papers on "The Chemistry of the Nitrifying Bacteria" were presented by Dr. H. Lees and Dr. T. Hofmann (Biochemistry Department, Marischal College, Aberdeen). The free energy efficiency of *Nitrosomonas* is usually taken to be about 6 per cent, but Dr. Lees has found that in the early stages of growth the value is about 50 per cent (biochemically a far more reasonable figure). The value falls rapidly as nitrite accumulates until, at nitrite concentrations of 1,500 μgm. nitrogen/ml., it has reached about 6 per cent. The rapid fall in efficiency may well be due to an increased respiration-loss consequent upon the maintenance of a low intracellular nitrite concentration in a medium of increasing nitrite content. Experiments on enrichment cultures of *Nitrobacter* have shown that the organism is highly sensitive to chlorate and that chlorate inhibition is reversed by nitrate; this accords with the results of percolation studies on soil. Dr. Hofmann, using the paper chromatography method of Fowden, has found that the amino-acid content of the protein of nitrifying bacteria does not differ fundamentally from the proteins of other less-specialized organisms.

Dr. James Shewan and his colleagues of the Torry Research Station discussed some aspects of the bacteriology of marine fish. The taxonomy of the groups present in marine fish is one of great difficulty, and a comprehensive study of these groups is at present being carried out. It has been found, for example, that it is very necessary, in order to explain different rates of spoilage in the same fish caught at the same time and handled and stored under identical conditions, to know not only the number but also the types of bacteria present. The three main families of bacteria found are Achromobacteriaceæ, Pseudomonadaceæ and Micrococcaceæ. The important species in these groups also show certain common characteristics, namely, capacity for growth in low concentrates of organic nutrients, enhanced growth on solid surfaces (presumably due to increased concentrates of organic nutrients on the solid surfaces), fairly low optimum temperatures (20°–25° C.) and marked heat sensitivity; they are actively proteolytic and usually weakly saccharolytic. Some have rather unusual biochemical characteristics, for example, liquefaction of agar, digestion of chitin and reduction of trimethylamine oxide; a few are luminescent.

A symposium on the chemistry and bacteriology of silage was presented during the conference. Dr. A. J. G. Barnett (Marischal College, Aberdeen) reviewed some recent studies on the estimation of the lactic acid content of silage and directed attention

to the fact that, while the lactic acid content of silage is directly related to *p*H, if the amount of lactic acid is re-calculated on the basis of the dry-matter content of the fresh silage, a similar curve results indicating that the lactic acid formed is proportional to the dry matter content of the initial crop. In further work, at present in progress, Dr. Barnett is studying the change of *p*H in relation to the lactic acid increase and the decline in sugar content.

Mrs. A. C. Stirling (College of Agriculture, Edinburgh) presented the results of preliminary experiments with grass silage made in laboratory containers under controlled conditions. Investigation of the bacterial content of such laboratory silage indicates that the fermentation proceeds more quickly at 30° C. than at 22° C. and that a temperature of 40° C. is selective of different types of organisms. Wilting of the grass delays bacterial action, whereas maceration gives a more rapid fermentation and a lower *p*H.

Miss R. E. A. Allen and Miss A. B. Dickinson (King's College, Newcastle upon Tyne) have investigated the variation in *p*H and total bacterial count (microscopical) in a pit of unmolassed grass silage. While they stress that it is not possible to draw final conclusions from the examination of a single pit, from their results it would seem that the variation of quality of silage in a pit, as measured by *p*H, is greater from top to bottom than from side to side. This agrees with the findings of Dudley and Townsend on the variation of crude protein and dry matter content through a cylindrical silo. Miss Allen's and Miss Dickinson's results were of interest in demonstrating the constancy of *p*H found in the middle layer of the pit.

Some preliminary results and suggestions on the role of plant cells in the ensilage problem were described by L. A. Mabbitt (Edinburgh). His paper dealt primarily with the problem of producing an apparatus which would be capable of doing all operations from sowing the seed to ensiling the fodder in the same sterile chamber. The illustration of Mr. Mabbitt's apparatus created considerable interest. Bacteriological examination of material obtained during 1950 showed that the 'silage' was sterile. Chemical analysis of the material showed that no alcohol, no volatile acid and no lactic acid were present. The amino-acid and volatile base content showed an increase. This work is also continuing.

The enumeration of lactobacilli on grass and silage has been studied by R. M. Keddie, Edinburgh. Mr. Keddie has found that addition of oleic acid and later 'Tween 80' stimulated the growth of lactobacilli. A medium containing 'Tween 80' and acetate in the form of an acetic acid/sodium acetate buffer was used at a final *p*H of 5·4. The medium gave good growth of lactobacilli apart from a group of homofermentative species. It is hoped from this preliminary work to develop a medium suitable for the enumeration of lactobacilli on grass and silage.

The methods hitherto used for the study of the anaerobic bacterial flora of silage have not been satisfactory. The development of an improved technique has been undertaken by R. F. Rosenberger (Edinburgh). Through the work of Barker in California the problem of the anaerobic fermentation of lactate has been largely solved, and, basing his work on Barker's conclusions, Mr. Rosenberger has been able to evolve a dilution method which appears to enumerate quantitatively the number of vegetative cells and spores of anaerobic lactate fermenters such as occur in normal silage. A similar method is being developed for the proteolytic anaerobes, based on the ability of these organisms to carry out an extensive protein breakdown in the absence of any other energy source, provided oxygen is excluded. With the introduction of semi-solid media and non-toxic reducing agents, thioglycollic acid and cysteine, a great advance has been made in anaerobic technique.

Dr. M. Ingram (Cambridge) recalled that experiments on whales have shown that the anaerobic bacteria (*Cl. welchii* type A) which occur naturally in whale flesh do not begin to develop actively until the muscles have passed through rigor mortis. Attempts to observe this effect on more normal meat (horse) have so far been unsuccessful, whether the flesh was incubated anaerobically with *Cl. welchii* as in the whale (artificial inoculation was necessary) or aerobically with species of *Pseudomonas*.

Some preliminary results on a small chlorinating plant suitable for farm water supplies were presented by Dr. L. F. L. Clegg (Wolverhampton) and W. A. Cuthbert (Leeds). The paper discussed the possibility and practicability of improving by chlorination those farm supplies used for dairy purposes which were either potentially dangerous or of such poor bacteriological quality as to be liable to affect the keeping quality of the milk produced. So as to overcome the difficulty of variation in the organic matter content, which in turn would cause a variation in the chlorine demand, super-chlorination followed by de-chlorination were employed. The principle of dosage was that of drawing in concentrated hypochlorite solution by a vacuum pump through a Venturi tube, followed by de-chlorination, on the same principle, with sodium thiosulphate. Incomplete sterilization was afforded with a dosage of 10 parts per million and a contact of 90 seconds, but satisfactory results were obtained by dosing at both 5 and 10 p.p.m. with a contact of 6¼ minutes. In order to reduce contamination from the sodium thiosulphate solution itself, it was found necessary to add a by-pass from the contact tank so as to leave a residual of 0·1–0·2 p.p.m. of available chlorine. Experiments are continuing using soil suspensions as contaminating material, and it is intended to study a prototype plant under farm conditions.

Two new experiments with the methylene blue test were described by H. Barkworth (Derby). In Mr. Barkworth's results, with replicate samples, the reduction time of methylene blue in milk diminishes with storage time, but this relationship ceases, or at least is seriously modified, when the reduction time has fallen to 30 min. These results cast suspicion on the value of any routine methylene blue test with an original reading of 30 min. or less, and since in the majority of cases tubes are read only at half-hourly intervals this means that any original reading less than one hour is of doubtful value.

Improvements in the ion-exchange method of preparing silica gel media (Taylor) was the subject of a communication from W. K. Smith (Butterwick Research Laboratories, Welwyn). This type of medium has a number of advantages and has created widespread interest. Mr. Smith discussed problems in the preparation of such media and described further applications.

The need for a rapid *in vivo* screening test for compounds of possible antituberculous activity has held the attention of workers in this field for some considerable time, and because of their small size, resulting in economy of drug and cost of maintenance,

much work has been done on experimental tuberculosis in mice. Miss Betty Croshaw (Boot's, Nottingham) dealt with attempts to standardize the screening test in mice using intracerebral infection, all results being based on the extent of lung tuberculosis when the experiments were deliberately terminated four to six weeks after infection. Miss Croshaw's paper also dealt with the virulence of cultures according to the type of culture medium used and the advantage of objective interpretation of drug activity (that is, survival-time).

A note on the bacteriology of yoghurt was given by Miss E. R. Hiscox (Reading). It would appear that this fermented milk consists primarily of a mixture of *Lactobacillus bulgaricus* and *Streptococcus thermophilus*. In some types yeasts may also be present.

Miss C. M. Cousins (Milton-Deosan, London) described a preliminary screening test (bacteriological) for quaternary ammonium compounds and formulations. The test is based on a plate count method which determines the survival of a given test organism, *Bacterium coli*, in sterile homogenized whole milk, added with the bacterial suspension to the quaternary ammonium compound dilutions, for an exposure time of two minutes. The paper directed attention to the special cleaning of glassware that is necessary. The preparation and use of the quaternary ammonium compound inhibitor, lecithin in 'Lissapol N', was described, with details of the testing procedure. Examples quoted showed how this test indicates a difference in bactericidal efficiency between (*a*) two different quaternary ammonium compound solutions, and (*b*) the same quaternary ammonium compound included in two powder formulations of differing *p*H value.

GENES AND MUTATIONS

THE Symposia on Quantitative Biology held annually in the Biological Laboratory at Cold Spring Harbor, Long Island, have become a major event in biology. Their purpose is to foster a closer relationship between biology and the other basic sciences, and they set out to achieve this not only by attempting a synthesis of existing experimental data concerning a particular subject, but also by applying new knowledge gained in other fields.

This year, the sixteenth of the series, the topic of discussion, selected by Dr. M. Demerec (Carnegie Institution), was "The Genes and Mutations". The same subject was discussed ten years ago, and the present meeting was intended to show the advances made in genetical research during the past decade. In 1941 the main subjects of discussion were the giant chromosomes of the salivary glands of *Drosophila*, the mechanism of chromosome coiling and spiralization, and the quantitative aspect of spontaneous and radiation-induced mutations. Only one contribution was concerned with the genetical usefulness of micro-organisms, viruses and bacteria. During the present Symposium the latter occupied a prominent position, and it was clearly demonstrated that the knowledge gained from studies of the genetical behaviour of bacteria, viruses and bacteriophage has deepened our understanding of the basic fundamentals of genetics themselves, and explained phenomena which baffled geneticists of ten years ago—as was so dramatically illustrated by T. M. Sonneborn (Indiana University) in the closing session.

A new theory of the gene, including its action in development and its relation to other genes, was brought to light by the work of B. McClintock (Carnegie Institution). She described very remarkable and complicated results on mutable genes in maize, which can be interpreted as due to transposition of minute pieces of chromatin from one position to another in the chromosome. The frequency of such transposition is itself under genic control, which findings emphasize the close integration or interrelationship of the gene complex. According to R. Goldschmidt (Stanford University, Cal.) the gene in the chromosome represents a "field of action" closely integrated into one system, in which gene mutation is a consequence of rearrangements on a submicroscopic scale. L. Stadler (University of Missouri) presented results on spontaneous gene mutation in maize, and E. R. Lewis (California Institute of Technology) on pseudoallelism in *Drosophila*. Both contributions have shown how it is possible by exact and extremely detailed genetical analysis to obtain insight into the complexity of genic activity. The same point was emphasized by S. G. Stephens (University of North Carolina) in describing the diversification of individual genetic loci in the diploid and amphidiploid forms of *Gossypium*.

Gene action and gene–enzyme relationship was discussed by D. M. Bonner (Yale University) and N. H. Horowitz (California Institute of Technology) in *Neurospora*. It was argued that there are genes which control only one step in the synthesis of enzymes, but an example in the synthesis of nicotinic acid was also presented to show that the blockage can be incomplete.

The genetical impact of chemical agents on genes and chromosomes was but little known in 1941. However, the present conference showed that the wealth of results obtained meantime in diverse organisms by the study of a great array of substances is not only impressive but also has widened our concept of mutagenesis itself and brought to light phenomena not observed previously. C. Auerbach (University of Edinburgh) pointed out the differences between chemically and X-ray induced mutations, by studying the mosaics in *Drosophila*, and emphasized the possibility of a delayed effect on the gene. Dr. Demerec described tests of various highly mutagenic compounds on the streptomycin-dependent mutant of *Escherichia coli*, which is a particularly suitable object for studies of the influence of environmental factors on gene-stability. On this aspect more evidence was presented by A. Hollaender (Oak Ridge National Laboratory, Tenn.) and collaborators, showing that lack of oxygen is one of the factors which greatly reduces the mutagenic effect of chemical agents and ionizing radiations. M. Westergaard (Institute of Genetics, Copenhagen) described his 'back-mutation' test in *Neurospora*, which will prove to be a very useful and rapid method for the detection of chemical mutagens, and made an attempt to interpret the chemical basis of induced mutagenesis. The aspect presented by Westergaard linked up closely with the contribution of N. H. Giles (Yale University), who described the various mechanisms which may be responsible for the spontaneous reversions of biochemical mutants in *Neurospora*.

The visible effects of various chemical agents on the chromosomes of *Allium* and *Vicia* were described by A. Levan (Institute of Genetics, Lund), who demonstrated that different chromosome regions may exhibit a different degree of reactivity to a drug,

suggesting that further investigation by genetical and cytological means may disclose specific affinities between certain chemical compounds and chromosome regions or even genes.

The broader evolutionary significance of mutagenesis was discussed by A. Gustafsson (Forest Research Institute of Sweden, Stockholm), who illustrated, with examples on barley, how new mutants produced artificially can be superior to the original type under different environmental conditions. W. L. Russell (Oak Ridge National Laboratory, Tenn.), by using an ingenious method of analysis, was able to present data obtained from about 85,000 mice, which show that the X-ray induced mutation-rate is at least fifteen times higher in this mammal than in *Drosophila*. Because of the great likelihood that man belongs more to the former than to the latter type in respect of radiation sensitivity, Russell's data add to the problem of radiation hazards in man a very serious emphasis, which was stressed by Prof. H. J. Muller.

The genetic composition of a population is known to be under the influence of various factors, such as mutation, selection, rate of reproduction, etc. A. Novick and L. Szilard (University of Chicago) have described the 'chemostat', which makes the study of these factors possible in bacteria. It is an apparatus in which the medium is automatically replaced so that the various growth-limiting factors may be added at a slower or higher rate than the reproduction of the bacteria. These workers illustrated with experimental observations the usefulness of the chemostat in genetical investigation, the results obtained being similar to those of K. C. Atwood (Columbia University) and co-workers employing the more conventional method of genetical analysis.

The Symposium devoted one session to the cytoplasmic constituents of heredity. P. L'Héritier (University of Paris) has proved that the sensitivity of *Drosophila* to carbon dioxide is due to a cytoplasmic factor, and closely resembles a virus-caused infection. He was able to show that by injecting extract from carbon dioxide-sensitive flies into resistant *Drosophila*, the latter 'acquired' carbon dioxide sensitivity. When the 'virus' or 'genoid' invades the germ-plasm, then the carbon dioxide sensitivity becomes a heritable property. L'Héritier favours the view that the 'genoids' have an internal origin. A more complex system of cytoplasmic inheritance was presented by B. Ephrussi (University of Paris) in yeast. He finds that the formation of large and small colonies, which differ also in the presence or absence of cytochrome-oxidase, is due to a nuclear gene, inducing an instability in the cytoplasm. The latter can be influenced or affected by environmental factors, such as the presence of trypoflavin in the medium, when the incidence of small-colony formation increases enormously.

A large part of the Symposium was taken up with the genetics of bacteria and bacterial viruses. J. Lederberg (University of Wisconsin) and co-workers gave a detailed review of bacterial genetics, derived from experiments with *E. coli*, line K.12. Lederberg pointed out the complex system of linkage relationships of known genetic loci in this bacterium. The inherent difficulties of bacterial heredity were further stressed by E. M. Witkin (Carnegie Institution), who analysed the method of segregation and recombination in multinucleate bacterial cells. The cytology of bacteria was presented by K. A. Bisset (University of Birmingham) and E. D. DeLamater (University of Pennsylvania). Their papers brought out the basic disagreements in the interpretation of the cytological phenomena, and further emphasized the difficulties of bacterial genetics.

The transformation of various morphological and serological types of pneumococci by deoxyribosenucleic acid extracted from particular mutants was reviewed by H. Ephrussi-Taylor (Institute of Genetics of the C.N.R.S., Paris), who presented new results suggesting that the 'old' genetic determinant is not only altered but is completely replaced by the 'transforming principle'. R. D. Hotchkiss (Rockefeller Institute of Medical Research) has induced penicillin-resistant pneumococci which have yielded another 'transforming principle' (deoxyribosenucleic acid), and was also able to show that by combining this with the morphological 'transforming deoxyribosenucleic acid' they 'segregate' independently. Another interesting case of transformation has been found by N. Zinder (University of Wisconsin) in *Salmonella*, in which a 'stimulating' substance must be liberated first, in order to produce the transforming factor itself. It is claimed that the latter is associated with the microsomes of the cytoplasm.

The various properties of bacterial viruses and their behaviour in heredity were described by S. E. Luria (University of Illinois) and A. O. Hershey (Carnegie Institution). It has been shown that genetical analysis is still the most powerful method by which not only the characteristics but also the organization of the bacteriophage itself may be studied. At the same time it has been possible to demonstrate in these 'simple' forms many of the features of a complex genetic system, such as exists in higher organisms. However, they also show other phenomena, such as 'phenotypic mixing', which at present remain unexplained.

The Cold Spring Harbor Symposium was an outstanding success since it brought together into a coherent and closely integrated system a great deal of new and fundamental information, obtained from studies on the most diverse organisms. It has emphasized two facts: first, genetics is making use of many new organisms and techniques and is thus at present extending its boundaries extremely rapidly and to great profit; and secondly, and consequent upon the specialization which is necessarily occurring, it becomes increasingly desirable to hold meetings such as this, at which the new fields may be integrated.

SECOND INTERNATIONAL CONGRESS ON ASTRONAUTICS

THE second International Congress on Astronautics was held in London during September 3–8. It was attended by nearly fifty delegates representing societies and groups interested in astronautics from Argentina, Austria, France, Germany, Great Britain, Italy, Spain, Sweden, Switzerland and the United States. The first International Congress, held in Paris in September 1950, was purely exploratory in nature and was intended as a series of informal meetings to discuss the possibility of setting up an international federation. As a result of the deliberations of the first two days of the recent Congress, an International Astronautical Federation was founded, "to promote and stimulate the achievement of spaceflight". Dr. Eugen Sänger was elected president, and the two vice-presidents are Dr. G. Loeser, of the Gesellschaft für Weltraumforschung, and Andrew G.

Haley, of the American Rocket Society. The headquarters are to be in Switzerland, and the Swiss group (there is as yet no legally constituted society) will handle all international matters, such as the collection, classification and storage of an astronautical library and archives. It is envisaged that the Federation's main tasks will be in the exchange of information between member societies and the organization of technical congresses. The next congress will be held in Germany in 1952.

The latter part of the London Congress was devoted to a symposium of papers on the general theme of orbital vehicles, their construction and uses. There was general agreement among the speakers that such vehicles are possible from an engineering point of view; the first instrument-carrying vehicles could be built within ten to fifteen years; but man-carrying artificial satellites appear to be much further in the future. In all, seventeen papers were read dealing with the engineering problems of raising and constructing such vehicles, return to earth by high-speed glider, travel between artificial satellite orbits, radar tracking of vehicles from the earth, danger from meteors and other relevant topics.

Mr. T. Nonweiler dealt with the problem of descent from a satellite orbit by glider. The most difficult matter is the temperature reached during the descent. In general, the rate of heat transfer to a body moving at very high speeds cannot be accurately calculated. However, Mr. Nonweiler presented an approximate general solution which he has developed and which is applicable at Mach numbers of 10 or more if the Reynolds number is between about 10^5 and 10^6. A return glider would, in fact, be operating within these limits during the greater part of its flight time. The effects of the air slip at the wing surface have also been examined; this has led to an estimate of the maximum rate of heat transfer to the surface. A limit to the skin temperature is also imposed by the conduction of heat along the surface: this has also been calculated. It was shown that the wing surface temperature will be a minimum if a thin, double-wedge wing-section is used, with a position of maximum thickness well aft and with both its inner and outer surfaces acting as good radiators of heat; the temperature will be highest near the leading-edge of the wing under-surface, and its value will vary approximately as the fourth root of the wing loading. If a maximum skin temperature of 1,300° C. be allowable, then it should be possible, for example, to construct an all-wing delta planform aircraft with an all-up weight of 20-tonnes capable of accommodating a payload of 5 tonnes.

In a paper entitled "Meteor Hazards to Space Stations", M. W. Ovenden extended both his own earlier work[1] and that of Grimminger[2]. Grimminger considered a space station of about 100 sq. m. exposed area and calculated the probable times between collisions with sporadic meteors of various magnitudes. The astronomical factors affecting the validity of Grimminger's analysis were examined. The existence of iron meteors was shown to require a reduction in the collision times by a factor of about 2. Radar observations provide direct evidence for the relationship between the assumed number of meteors to their magnitude down to magnitude 7, but extrapolation beyond this limit is uncertain because processes exist which might disturb the distribution. One such process is the sun's radiation pressure, which would repel all meteors smaller than magnitude 30 out of the solar system. Another process affecting much larger meteors is the Poynting-Robertson effect. This may increase Grimminger's times by a factor of about 3, although a much greater possible increase cannot be ruled out. The danger from meteor showers is comparable with that from sporadic meteors. The greatest uncertainty in the estimates of collision times is due to the imperfect knowledge of the mass of a meteor of given magnitude. Error here may require, at worst, a decrease in collision times by a factor of 50. The use of a very thin 'meteor bumper' around a space station, which would explode any incident meteors, was suggested for space stations intended for use for a period of more than about a year.

The greatest problem of interplanetary flight is that of propulsion, and in his paper "Interplanetary Travel between Satellite Orbits", Prof. Lyman Spitzer discussed a method of applying nuclear energy. It was suggested that an electrically accelerated ion beam could be used for achieving a gas ejection velocity of 100 km./sec. without the use of very high temperatures in the propellant gases. Such a unit could not be built with a large enough thrust/weight ratio to allow it to take off from the surface of a planet. It would be capable of travelling from a close-orbital station about the earth to a similar orbit about any other planet. The mass flow of the working fluid in an ion rocket would be low, and hence interplanetary vessels of a very low mass ratio could be built.

In "Biological Problems of the Earth Satellite Vehicle", Médecin-General P. Bergeret discussed the conditions under which the human body would have to function in an artificial satellite. One of the major unknowns is the effect of zero g or 'free fall' conditions. This condition can be obtained for periods up to 10 sec. in high-speed jet aircraft. Artificial gravity may be necessary and this can be obtained by rotating the vehicle.

J. Humphries

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STRESS ANALYSIS

The fifth annual conference of the Stress Analysis Group of the Institute of Physics was held during April 4–6 in the Mechanical Engineering Laboratory of the University of Liverpool. Papers were read on relaxation methods, fatigue, applications of electric resistance strain-gauge methods, brittle lacquer methods, a pneumatic strain-gauge, applications and problems of the 'frozen stress' method of photoelasticity, and hydraulic methods of applying test loads.

The opening lecture of the conference was given by Prof. D. G. Christopherson on "Numerical Methods in Stress Analysis with Special Reference to the Relaxation Method". He outlined the development of the application of numerical methods to stress analysis problems, emphasizing the different approach of the mathematician and the engineer. The mathematician faced with an insoluble differential equation or an unreasonably large number of simultaneous linear equations seeks for more rapid means of obtaining an approximate solution. The engineer, on the other hand, concerned in the first place with problems of complicated structural frameworks, rejects the traditional apparatus of analysis and seeks for help in processes in which experience, intuition and imagination about the probable

behaviour of the structure can play as large a part as mathematical ability. Prof. Christopherson referred to the moment-distribution method of Hardy Cross as one such method. Sir Richard Southwell's relaxation method was also first applied to problems of frameworks, and although the greatest successes of the relaxation method have been won in fields remote from structural engineering, the nomenclature of the method still shows its original applications.

Prof. Christopherson dealt with several types of problems of importance in stress analysis, demonstrating how they can be tackled, how the accuracy of a solution can be improved or at least reliably estimated, and how previous experience or intuitive knowledge of the type of stress distribution to be expected can all be made to give a more rapid convergence and therefore a quicker solution.

The two papers dealing with electric resistance strain-gauge work were by P. H. Wolfenden, on the use of these gauges for the measurement of transient forces in power looms, and by R. G. Boiten, on the determination of residual stresses, respectively. The latter dealt with the problems encountered when it is not possible to take the structure under investigation through a loading cycle while the gauges are in place. This arises mainly when determining stresses due to the self-weight of a structure such as a bridge, and when investigating locked-up stresses such as those due to welding. The method described by Mr. Boiten consists essentially of the measurement of the change of stress around a circular area 6 mm. in diameter. Three gauges are placed radially as close as possible to the area, which is then removed by drilling a hole of that diameter. From the change of stress observed the original locked-up stresses can be computed on the generally sound assumption that the stresses are reasonably uniform over the small circular area. Considerable care under what must often be field rather than laboratory conditions is required in the placing of the gauges and the hole.

Dr. D. G. Sopwith, in a lecture on "Fatigue", dealt with the subject of the failure of components or structures under repeated loads from the point of view of the designer or stress analyst rather than that of the metallurgist. He discussed the correlation of the safe stresses under fatigue conditions with other physical properties of the material and also the influence of factors such as temperature and corrosion on the behaviour of a specimen subject to repeated loading.

Dr. A. W. Hendry and J. K. Tattersall, and G. Robertson described work they have done using the 'frozen stress' method of photoelasticity, which makes use of a phenomenon observed in certain photoelastic model materials—namely, that a model subjected to load and taken through a heating and cooling cycle retains the relevant fringe pattern after the load has been removed and can even be sliced without the resulting slices losing their 'frozen' pattern. Dr. Hendry and Mr. Tattersall have used the method to analyse the stresses in a buttress dam of a hydroelectric power scheme in Scotland. They dealt separately with the stresses induced by the water pressure and those due to the weight of the dam. The former were tackled by ordinary 'frozen stress' methods using 'Catalin' as their model material. The latter posed a more serious problem since none of the usual photoelastic model materials capable of being sliced is sufficiently stress-optically sensitive to show fringes under its own weight. To simulate a gravitational field using a centrifuge necessitated the use of the longest convenient rotor arm so that the body force on the model should be reasonably uniform throughout the depth of the model. This made it impossible to spin the model in the oven as is usual; it would have involved the use of an impossibly large oven. To overcome this difficulty the model was heated in an oven and then transferred very rapidly in a heat-insulated box to the centrifuge, where it cooled slowly while being spun.

Mr. Robertson's work dealt with the stresses in pipe flanges. He used the comparatively new American material 'Fosterite', with which he could find no fault apart from its very high cost. He overcame one difficulty which is inherent in the analysis of three-dimensional problems by the 'frozen stress' method, this difficulty being that the slices cut from the three-dimensional models should be as thin as possible, as they are treated afterwards by the methods of two-dimensional photoelasticity. Very thin models, however, display very few fringes, since the fringe order at a point is proportional to the thickness of the model as well as the principal stress difference. Thin slices, therefore, require accurate measurements of fringe order by compensator methods. Having had to deal with a solid of revolution, Mr. Robertson was in a position to cut a large number of radial slices which by symmetry were identical. He made these slices thin enough to meet the requirement that the stresses should be reasonably constant through the thickness of the slice, but obtained satisfactory fringe photographs by using a pile of half a dozen or more slices superimposed on each other. The fringe photographs obtained in this way were strikingly well defined.

H. de Leiris discussed the development of brittle lacquer methods and of a pneumatic strain-gauge of very short gauge-length. He compared the fusion technique of applying strain-sensitive lacquers with the dissolving technique exemplified by such commercially available lacquers as 'Stresscoat' and 'Strainlac'. He discussed the relative merits of using different criteria such as the appearance of the first crack, the crack density or the lengths of the cracks when interpreting crack patterns. He dismissed the first two criteria as unsatisfactory, being dependent on variations in the thickness of the lacquer and other fortuitous circumstances. He was in favour of the method by which a family of curves, one for each increment of load, is obtained by drawing a line through the extremities of all the cracks. This method has the merit of dealing with a large number of cracks each time, thereby eliminating the effect of some of the random variations. M. de Leiris emphasized the important part played by the contraction stresses in the lacquer which are present before any load has been applied to the specimen. The load is, in fact, only the proverbial last straw which makes the lacquer crack. He therefore found it difficult to envisage any mechanism of failure which did not in some way require a tensile stress to open the crack. No simple law of cracking has as yet been suggested. There is, all the same, no doubt that the brittle lacquer method used as an auxiliary to more accurate methods of analysis fulfils an important function. In the second part of his paper M. de Leiris described a pneumatic gauge operating on the 'Solex' principle. This instrument has a gauge-length of 2 mm. with a magnification of 200,000; a stress of 1 kgm./sq. mm. in steel is indicated by a change of level of 20 mm. on a manometer.

E. K. FRANKL

LETTERS TO THE EDITORS

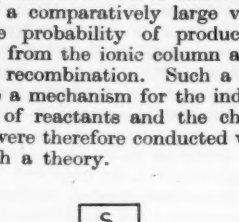
The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Chemical Effects in Liquids due to α-Particle Irradiation

A CONSIDERABLE amount of research has been carried out on the chemical effects which are produced by alpha-particles in liquids. So far, no satisfactory theory has been proposed to account for the fundamental processes involved in these reactions. From early studies, extended by recent work in this Department, of the ionization currents which can be collected from liquids, it is clear that the vast majority of ions recombine almost immediately. Jaffé[1] has shown in his 'column theory of ionization' that in liquids the half-life for recombination is 10^{-7} sec., due to diffusion alone. It has been pointed out by Kramers[2] that, due to the intense electrostatic fields which must exist in such columns of ionization, the half-life should be substantially reduced. It therefore appears impossible to explain the main features of the chemical experiments simply in terms of the production of ions, especially in view of the independence of chemical yield upon concentration of the reactants.

It has already been reported that quanta are emitted from thin films subjected to α-particle bombardment[3], and we considered that the chemical effects might be due, at least partly, to quantum emission associated with the intense ionization. As in the experiments with thin films, this radiation would be readily absorbed by the parent material, possibly producing free radicals within the solvent.

While the radiation length is small compared with the bulk of the liquid, it is large compared with the estimated diameter of the ion columns. In this manner, the production of free radicals can be distributed over a comparatively large volume, hence increasing the probability of producing chemical effects remote from the ionic column and independently of ionic recombination. Such a basic process would provide a mechanism for the independence of concentration of reactants and the chemical yield. Experiments were therefore conducted with the view of testing such a theory.



The experiments took the form of irradiating a thin film of water with α-particles. A sample of a suitable aqueous solution was exposed to the quanta which might be liberated from the thin film. The diagram shows the experimental arrangement. The source *S*, about 20 millicuries of polonium, was placed about 0·5 cm. above a quartz slide 1 mm. thick. A film of water, of a thickness less than the equivalent range of the α-particle, was maintained on the upper surface of the slide. A reaction vessel, *L*, containing about 1·5 c.c. of solution, was placed immediately below the slide. The solutes investigated were ferrous ammonium sulphate, chloracetic acid and sodium iodide; in each case the solvent was water. Colorimetric methods were used for determining the yields of ferric, chlorine and iodine ions respectively. The water films were subjected to α-particle irradiation for periods of up to eleven days. Control experiments were performed to determine the amount of chemical change due to other conditions and due to the irradiation of the quartz by α-particles. Such control effects were in general negligible. Experiments were also carried out in which similar solutions were irradiated directly by α-particles.

A comparison of the results showed that chemical effects, between a twentieth and a twenty-fifth of the yield obtainable from direct bombardment, were found when the thin water films were irradiated. Recent improvements of the measurements reported previously[3] have provided an estimate of the absorption length of the quanta in the thin films. It appears that the ratio of the numbers of quanta emerging from the thin films in the above chemical experiments to the total number of quanta produced by the α-irradiation is of the same order of magnitude as the above ratio of the two chemical yields. These results suggest that the bulk of the chemical effect produced by α-particles in liquids can be explained by secondary effects of quantum emission arising from the primary ionization.

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Surface Cells of Feather Barbs

FROM Strong's[1] drawings it is evident that those cells of the cortex of the feather barb which lie nearest to the surface are flattened. No author, however, has directed attention to the fact that these cells differ in structural detail from the rest of the cortical elements. The surface cells of the feather barbs appear to form a pattern similar to some of the cuticular scale patterns seen on animal hairs. It was found that this pattern could be shown by making casts of the barbs in the same way as casts of animal fibres are made.

These casts were made in polyvinyl acetate; a thin layer of a 20 per cent solution of polyvinyl acetate in benzene was spread on a microscope slide and heated to drive off the benzene. Feather barbs were then placed on the plastic layer and another slide placed on top; these slides were then placed on an electric hot plate and pressure applied (the load applied was approximately 6 lb. over the whole slide). A small piece of polyvinyl acetate was placed on another slide adjacent to the first slide and used as a temperature guide; when it had softened the current was switched off, the slides were allowed to cool while still under pressure, and the barbs afterwards removed from the slides and the casts exam-

Cast near base of barb of Guinea fowl. × 400

med. Where the surface cells appeared to be thicker, additional weights were added to give a load of approximately 10 lb.

The first casts made were of barbs without barbules; but later it was found that the presence of barbules made very little difference to the casts. Barbs from the feathers of Guinea fowl, 'Silky' fowl and *Chlorophanes spiza* (Cœrebidæ) were examined in this way. The patterns formed by all these show a network of polygons arranged with their long axes parallel to the length of the barb. Thus the surface cells are of a different shape from those within the cortex, which are long and similar in shape to the cortical cells in mammalian hair.

In some instances, for example, the reverse side of the barb of the Guinea fowl, the following details can be seen in the cast: (1) an oval area corresponding to the original position of the nucleus in each cell; (2) coarse striations; and (3) fibrillary structures. The close moulding of the thin 'surface cells' to the cortex proper may be the reason why the coarse fibrillary striations, arranged in parallel in the cortex proper, are visible in the cast. The patterns formed by the fibrillary structures within the surface cells are not always clearly visible in the casts of all feather barbs; but in the cast of the reverse surface of the barb of Guinea fowl the pattern formed by these structures can be seen superimposed upon that formed by the parallel fibrillary striations of the cortex proper. This pattern gives the effect of a delicate cross-hatching with a distinctly longitudinal trend within the network formed by the boundaries of the surface cells (see photograph).

Further evidence of cell boundaries is seen in transverse sections of the feather barb of the Guinea fowl. Indentations can be seen in the surface margin of the reverse side of the barb when thin (one micron) unstained sections are viewed by phase-contrast using 1/12 in. oil-immersion objective.

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July 24.

[1] Strong, R. M. *Bull. Mus. Comp. Zool. Harvard*, **40**, 147 (1902).

Sedimentation in the Tropical Indian Ocean

As a result of recent investigations[1] into the distribution of the Radiolaria in the sediments collected by the Swedish Deep-Sea Expedition in the Western Pacific Ocean, two conclusions of outstanding importance can be drawn: first, that several species of Radiolaria which are widely distributed in the tropical oceans of the present day do not extend farther back in time than the very latest Tertiary or early Quaternary; secondly, that erosion and re-distribution of older sediments on the deep-sea floor often result in the mixing of the tests of Tertiary Radiolaria with Recent ones in that region.

With the object of determining whether either of these effects could be found in the sediment cores collected by the Expedition in the tropical Indian Ocean, a preliminary examination was made of the Radiolaria from samples taken at 1-metre intervals in the following cores:

Core No.	Position		Depth
	Lat.	Long.	
125	S. 10° 07′	E. 108° 56′	6,875 m.
127	S. 11° 07′	E. 103° 39′	5,650 m.
128	S. 11° 28′	E. 102° 24′	5,170 m.
137	N. 01° 56′	E. 88° 12′	4,300 m.
141	N. 02° 18′	E. 76° 02′	3,765 m.
142	N. 00° 35′	E. 75° 14′	4,050 m.
143	S. 00° 31′	E. 74° 33′	3,314 m.
145	S. 01° 20′	E. 68° 20′	3,620 m.
147	S. 01° 19′	E. 66° 16′	4,380 m.
149	S. 01° 22′	E. 62° 38′	4,750 m.
154	S. 00° 23′	E. 54° 30′	4,860 m.
155	N. 04° 28′	E. 52° 48′	5,117 m.

This examination showed that all the characteristic present-day tropical species occurred in all cores at all levels—even those species which are known to have short time-ranges do not disappear at the bottoms of the cores. No Tertiary Radiolaria were found in any of the samples examined.

From these results it can be concluded that, along the course of the Swedish Deep-Sea Expedition in the Indian Ocean, there is no locality where Tertiary sediments have been laid bare by bottom currents which have eroded them and re-distributed their components. This is in strong contrast to the results from the Western Pacific Ocean, where such effects of current erosion seem to be widespread.

The reason for this difference in the results from the two oceans probably lies in their different geological histories. The floor of the Indian Ocean has been a region of comparative tectonic quiet since the Eocene. Thus there have been no major changes in the topography of the sea-floor which would result in widespread re-distribution of sediments. The Western Pacific, on the other hand, was a region of considerable diastrophic activity at the close of the Tertiary, and therefore late Tertiary sediments in that area must often have been brought into the sphere of action of bottom currents.

Even though there is no evidence of recent erosion of Tertiary sediments in the tropical Indian Ocean, it is not impossible that Quaternary sediments are being moved, to a certain extent, by bottom currents. Nevertheless, the magnitude of this process must be much less than in the Western Pacific.

For the facilities for carrying out this investigation, I am indebted to Dr. B. Kullenberg, of this Institute.

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[1] Riedel, W. R., *Medd. Oceanogr. Inst. Göteborg*, No. 19 (1951).

Cone Electroretinography by Flicker

It is generally assumed that the *b*-wave of the human retinal action potential is due to the stimulation of the rods. With an intensity of 2,000 lux, the *b*-waves fuse at a frequency of about 20 flashes per second. At lower intensities the fusion frequency in our experiments decreased. A linear relation was found between fusion frequency and the logarithm of stimulus intensity. However, the subjective fusion frequency, determined by cone activity, is known to reach values around 50–60 flashes per second. These high values are never obtained with the *b*-waves of the electroretinogram as index. This is but one of several reasons for assuming the *b*-waves to express rod activity.

According to Karpe and Tansley[1], the threshold of the scotopic *b*-wave of the electroretinogram is higher than the sensory threshold. In agreement with expectations from the general theory of the electroretinogram[2], Adrian[3] found the photopic electroretinogram to be characterized by larger initial negative *a*-waves. It was therefore held that flicker at very high light-intensity might give evidence for cone activity by changing into (negative) *a*-wave flicker from the low-frequency (positive) *b*-wave flicker. This proved to be the case. When we increased the light-intensity until the *b*-waves were preceded by well-developed *a*-waves, the *b*-waves decreased (Figs. *A–C*) and the *a*-waves increased (*B–C*) as flicker frequency rose (see legend of diagram). The *b*-waves disappeared at a flash frequency of about 20 per sec. The negative *a*-waves appeared to have maximum amplitude at about 25–35 flashes per sec. It seems very likely that their quick return after each flash is due to a true off-effect. This off-effect becomes more pronounced if the *PII* component of Granit's analysis has been removed. Onset of fusion of fast flicker was accompanied by decrease of amplitude. It depended upon stimulus intensity in the same way as the *b*-flicker at lower intensities. Fusion coincided with sensory fusion. The highest fusion frequency observed was at about 55 flashes per second. A reduction of light-intensity to one-tenth reduced the fusion frequency to 35.

From the results obtained by Granit[2], it appears likely that the decrease of the subnormal *b*-waves with increasing frequency of stimulation by intermittent light is caused by an accumulation or increase of post-excitatory inhibition. The amplitude of the rapid potential changes, *a*-wave and off-effect, goes on increasing even after the fusion frequency of the rods has been exceeded. Actually the human retina, which to the ordinary range of stimulus intensities behaves like an *E*-retina, turns into an *I*-retina at higher intensities. Similar transitions are known for other eyes (for example, frog[2]), and the suppression of the *I*-properties at lower intensities has been ascribed to a general inhibition exerted by the rods on the cones.

Enroth[4] has recently shown that the limiting conditions for fusion in individual retinal elements of the cat's eye can be strictly determined. Fusion in, for example, an off-response results if the difference between the latencies of the off-response and the pre-excitatory inhibition is equal to the length of half a flicker period. We assume that the fusion of the rapid potentials in the human retina follows a similar pattern.

These observations are of some general interest because they seem to offer means of studying objectively the photopic function of the human retina.

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Katharinenstr. 29/III. July 3.

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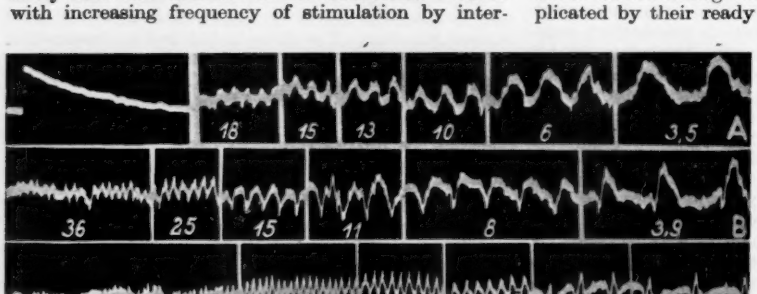
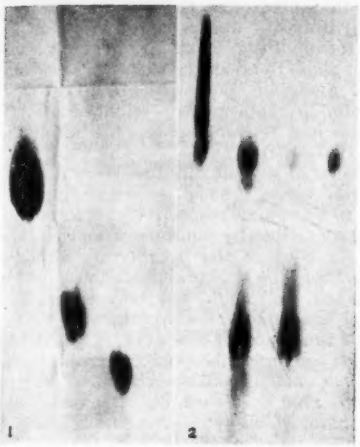


Flicker electroretinogram at different intensities and frequencies of stimulation. The numbers in each row give the frequencies. Upper row, (*A*): intensity approximately 2,000 lux. Fusion of the sub-normal *b*-waves occurs at 18 stimuli per second. Middle row, (*B*): intensity approximately 2,600 lux; the *b*-waves are preceded by negative *a*-waves, the amplitude of which *I* increases with increasing frequency. Simultaneously the *b*-waves decrease in amplitude. Fusion frequency is 36 stimuli per second. Lower row, (*C*): intensity approximately 24,000 lux. After passing the fusion frequency of the *b*-waves, the *a*-potentials display a further increase in amplitude the maximum of which is reached at about 25–35 stimuli per second. Fusion at 53 stimuli per second. Calibration, upper left-hand corner, 0·1 mV.; time marker, 1/10 sec.

Paper Chromatography of the Pyrogallol Tannins

By one-dimensional paper partition chromatography, some of the phenolic substances allied to the pyrogallol tannins have been separated. When using the well-known solvent phases such as butanol/acetic acid and phenol, previous workers[1] have found that the simpler phenols tend to give long diffuse trails. The preparation of the more complex phenols, such as are found among the pyrogallol tannins, is complicated by their ready oxidation in the presence of bases. Tailing of the spots in neutral and acidic solvents is influenced by the acidity of the mobile phase (cf. organic acids[2]). Addition of strong organic acid to the eluting solvent causes separation into well-defined spots. Unfortunately, formic acid greatly increases the rate of run of the tannin, the spots coming too close to the solvent front for clear definition. Two new solvents have now been found which separate many mixtures of complex phenols into well-defined spots: (1) phenol/acetic acid/water, prepared by adding 30 ml. glacial acetic acid to approximately 500 ml. liquid phenol and just saturating



(1) Phenol/trichloracetic acid/water. Left to right: digalloyl glucose, gallic acid, split acid.

(2) Phenol/acetic acid/water. Left to right: gallotannic acid, synthetic pentagalloyl glucose, synthetic pentagalloyl glucose after passage through column of 'Amberlite *IR4b*', gallic acid

with water at room temperature; (2) phenol-trichloracetic acid/water, prepared by adding 35 gm. trichloracetic acid to approximately 500 ml. liquid phenol and just saturating with water at room temperature.

Spots containing approximately 20 μgm. of each substance are eluted down Whatman No. 4 paper and the chromatograms are dried thoroughly and sprayed with ammoniacal silver nitrate solution (0·1 *N*), when the separate substances appear as black spots in the cold. The R_F values of the different tannins vary considerably with temperature, and for identification purposes it is more reliable to run control spots than to use the mathematical technique.

Employing this method, it has been possible to separate widely different types of compounds, such as chebulinic acid[3] and its hydrolysis products, digalloyl glucose, split acid and gallic acid (Fig. 1). The method has been used to check the purity of synthetic and naturally-occurring amorphous pyrogallol tannins. Thus synthetic amorphous pentagalloyl glucose, prepared via the acetyl derivative, contains at least four compounds (Fig. 2) and is not, as assumed, a single substance. Similarly gallotannic acid, when free from gallic acid, contains more than one compound, none of which is present in impure synthetic pentagalloyl glucose. Hydrolysis of gallotannic acid and similar complex materials by acid, or water in sealed tubes at 100° C., gives pyrogallol as well as gallic acid, indicating that some decomposition occurs.

The pyrogallol tannins of *Terminalia chebula* (Myrobalans) have been separated using the two solvents. A more detailed account of this work will be reported later.

I am indebted to the Council of the British Leather Manufacturers' Research Association for a grant and permission to publish this note.

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June 4.

[1] Evans *et al.*, *Nature*, **164**, 674 (1949).
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[3] Fischer and Freudenburg, *Ber.*, **52**, 1238 (1919).

Paper Partition Chromatography of Some Organic Bases by the Method of N-Methylation

The precipitate formed between organic basic substances and Dragendorff's reagent is influenced by the valency of the basic nitrogen atom and by hydrophilic groups, such as carboxyl, hydroxyl, etc.[1]. Difficulties in the use of this reagent can often be overcome by a preliminary N-methylation.

The procedure recommended is as follows. Place a small quantity of an aqueous or methanolic solution of the basic substance not reacting readily with Dragendorff's reagent, such as ephedrine, the sulpha drugs, marfanil, benzedrine, etc., on a paper strip and develop it for about twenty hours in butanol acidified with acetic acid (butanol : water : acetic acid = 5 : 4 : 1) by the ordinary procedure of paper partition chromatography (ascending method). After drying, a 10 per cent aqueous solution of potassium carbonate is sprayed on the paper strip and the drying repeated. The paper strip is then immersed in dimethyl sulphate, pressed between layers of filter papers using a rubber roller in order to remove excess reagent, and warmed to 90° for ten minutes in an air bath to complete the N-methylation process.

On spraying with Dragendorff's reagent (diluted five times with 70 per cent acetic acid), a red or reddish-orange colour is revealed at the positions occupied by the basic substances with quaternary nitrogen atoms. The method is also applicable to the extracts of crude drugs.

Examples of R_F values of basic substances obtained by this method are as follows:

(±)-Ephedrine hydrochloride	0·78	Nicotinic acid	0·75
(−)-Ephedrine hydrochloride	0·82	Pyridoxine	0·61
(+)-Ephedrine hydrochloride	0·79	Sulphapyridine	0·82
Marfanil	0·43	Theobromine	0·56

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[1] See *J. Pharm. Soc. Japan*, **70**, 721 (1950); *Jap. J. Pharm. Chem.*, **22**, 468 (1950); cf. also Sakaguchi, T., *J. Pharm. Soc. Japan*, **65** (1945).

Detection of Enzymes by the Agar-Plate Method and its Application to Paper Chromatography

In a communication under the above title, Giri[1] describes the use of a starch agar gel for the location of amylases on the paper chromatogram. The technique seems to be essentially the same as that used in this Department, and previously described in *Nature*[2].

The following comments may be made on the technique. Giri[1] obtains marked movement of certain amylases with 50 per cent acetone, whereas, in this laboratory, 50 per cent acetone produces little, although 40 and 30 per cent acetone show marked movement; this may be due to the higher ambient room temperature in Giri's experiments. Most enzymes examined show a marked tailing effect even

with low concentrations, which is not apparent unless the time of incubation on the gel is prolonged (18–24 hr.). With the exception of polygalacturonase and pectin-esterase, it has not been possible to separate enzymes, as each is resolved into two or more components and the components from different enzymes frequently overlap. The exact status of these components is as yet undetermined; for example, the number of components and the resulting pattern of the gel-developed chromatogram vary with amylases from different sources. In general, solvent – water mixtures are preferable to aqueous salt solutions as developing agents.

Mitchell, Gordon and Haskins[3] found that both adenosine-deaminase and amylase could be resolved into components on a pile of filter paper disks with ammonium sulphate solutions as developing agents.

It is probable that the chromatographic technique is comparable to electrophoresis in that it separates enzyme proteins due to differences in physical properties rather than differences in enzymic behaviour, for example, kinetics. The R_F-value has been of little use in this technique, as it is markedly affected by slight changes in the conditions of development.

Full experimental details are being submitted for publication elsewhere.

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June 19.

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Chromatographic Evidence for the Tetraphosphate Ion

A knowledge of the structure of phosphorus pentoxide, P_4O_{10}, enables predictions to be made concerning the mechanism of its hydration to orthophosphoric acid and particularly about the structures of the phosphoric acids formed intermediately[1]. In order of their formation, these would be expected to be $H_2P_4O_{11}$, $H_4P_4O_{12}$ (tetrametaphosphoric acid), $H_6P_4O_{13}$ (tetraphosphoric acid) and eventually mixtures of $H_5P_3O_{10}$, $H_4P_2O_7$ and H_3PO_4. Salts of tetrametaphosphoric acid have already been isolated and identified by X-ray and other methods from the alkaline hydrolysate of P_4O_{10}, and we have explored the use of paper chromatography as a means of separating the tetraphosphate ion. Aqueous solutions which would be expected to contain the latter were made by controlled alkaline hydrolysis of sodium tetrametaphosphate, using conditions analogous to those giving sodium triphosphate from sodium trimetaphosphate and similar to those described by Thilo and Rätz[2].

Chromatographic evidence for the existence of the tetraphosphate ion was obtained at Cambridge by one of the authors in association with Dr. C. S. Hanes using the techniques developed by Hanes and Isherwood[3] in their study of phosphoric esters. This chromatic evidence has been confirmed in detail by further work at Toronto.

In both laboratories the sodium tetrametaphosphate hydrolysate was prepared by heating 1 gm. of the tetrahydrate for 2 hr. at 70° C. with just sufficient alkali to break the ring. This was chromatographed alongside pure specimens of the orthophosphate, pyrophosphate, triphosphate, trimetaphosphate and tetrametaphosphate kindly supplied by Dr. B. Raistrick.

A number of solvent mixtures were used, of which *n*-propanol, water, 0·88 sp. gr. ammonium hydroxide (60, 20, 20 by volume respectively) is a good example. A strong spot which by colorimetric analysis accounted for 60 per cent of the hydrolysate appeared in a position where the tetraphosphate ion might logically be expected, and could not be ascribed to any of the other anions conceivably present.

During the course of this work, it was noted that a separation of orthophosphate, pyrophosphate and triphosphate anions could be obtained. Furthermore, it was observed that a sample of commercial sodium triphosphate, which by usual methods of analysis had a pyrophosphate content of 3–10 per cent, gave on chromatographic analysis two spots, the fainter one occupying the pyrophosphate position. It would seem, therefore, that a chromatographic separation of the phosphate anions should lead to an improved method for their quantitative analysis.

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Vapour Pressure of Isotopic Carbon Tetrachlorides

A theory of the vapour pressure relationship for isotopic molecules has been given by Topley and Eyring[1]. It is, however, difficult to see *a priori* how to apply the theory in calculating vapour pressures for a particular case, in view of our lack of knowledge of the liquid state. The isotopic molecules of carbon tetrachloride would be expected to be very favourable cases for showing differences of vapour pressures if they exist. Grimm[2] carried out a multiple fractionation with a single small packed column and calculated that neighbouring isotopic molecules on the mass scale had boiling points not differing by more than 0·001° C. We have calculated from Grimm's results that his total fractionation was equivalent to 75 theoretical plates.

Modern packed columns have much higher efficiency and can be operated automatically. We have made use of three packed columns constructed by Dr. Newell Cook of the Chemistry Department of this College in an attempt to fractionate the isotopic molecules of carbon tetrachloride.

These columns have probable theoretical plate ratings of 100, 200 and 400 plates respectively, and are completely automatic in operation. We have operated the columns in such a manner that the first distillate was charged into the second column, etc. The reflux ratio used was 1,000 : 1. The last column was brought to equilibrium, and the specific gravity of the equilibrium mixture relative to the original

charge of the first column determined. Since the first column was continued in operation after it had furnished its charge to the second column, a cut was taken near the end of the distillation and this sample compared with the top of the third column.

The specific gravity was determined by the buoyancy balance method described by Lewis and MacDonald[3], which had a sensitivity at least as great as 1·8 in the fifth decimal place. We were not able to detect the slightest difference in the density of the various samples.

Carbon tetrachloride is particularly favourable for such a fractionation experiment, since one can be sure of its purity to a degree unable to affect the density to the above precision by examining the infra-red spectrum in a liquid cell 1 cm. or greater in thickness.

Since the experiment gave completely negative results, it is only possible to calculate the maximum possible difference in the vapour pressures from the sensitivity of the apparatus. If we make a few reasonable assumptions, this is easily accomplished.

If A is the fractional part of chlorine of mass 35 and B the fractional part of chlorine-37, that is, $A + B = 1$, statistically the population of the five types of isotopic molecules will be given by the expansion of $(A + B)^4$. Each term of this expansion is identically equal to the mole fraction M_i of the particular molecule A_nB_m, where n and m represent the number of chlorine atoms of the mass in question.

We shall assume that the difference in vapour pressures of progressively heavier isotopic molecules varies linearly with increased mass. We shall make a further but somewhat doubtful assumption to simplify the calculations, that free statistical exchange of isotopic chlorine atoms is possible. This assumption in any event will not greatly affect the result. We can now write the following relationships :

$$M_1 + M_2 + M_3 + M_4 + M_5 = 1; \quad (1)$$

$$M_1^* + M_2^* + M_3^* + M_4^* + M_5^* = 1; \quad (2)$$

where the M's refer to the mole fractions of the various isotopic molecules and * quantities refer to enriched samples. If p is the vapour pressure of the most volatile molecule, namely, $C^{35}Cl_4$, the relative volatilities will be

$$1, \frac{p-\delta}{p}, \frac{p-2\delta}{p}, \frac{p-3\delta}{p}, \frac{p-4\delta}{p}. \quad (3)$$

δ is obviously the difference in vapour pressure between neighbouring isotopic molecules on the mass scale. The composition of the distillate will be given by :

$$M_1 + M_2\left[\frac{p-\delta}{p}\right]^n + M_3\left[\frac{p-2\delta}{p}\right]^n + M_4\left[\frac{p-3\delta}{p}\right]^n + M_5\left[\frac{p-4\delta}{p}\right]^n = S, \quad (4)$$

where

$$M_1^* = \frac{M_1}{S}, \; M_2^* = \frac{M_2}{S}\left[\frac{p-\delta}{p}\right]^n, \ldots M_5^* = \frac{M_5}{S}\left[\frac{p-4\delta}{p}\right]^n,$$

and n is the number of theoretical plates.

From the minimum detectable density change, it is possible to calculate the minimum detectable change of molecular weight, and thus to calculate the quantities M_1^* from the new values for A^* and B^* inserted into $(A^* + B^*)^4$. Solution of equation (4) is now easily possible and yields a value of δ of $1{\cdot}4 \times 10^{-3}$ mm. of mercury for a value of n of 700 theoretical plates and a change of specific gravity of 1·8 in the fifth decimal place.

From this result it follows that neighbouring isotopic molecules do not differ in boiling point by more than 6×10^{-5} degrees centigrade. It is conceivable that the vapour pressure differences of these isotopic molecules could be greater than we have calculated. Cohen[4] has shown that when fractionation processes are carried out with materials of very close boiling points, the equilibrium times become extremely long and minor disturbances have a large effect on the efficiency of the column. The net effect is, of course, a marked reduction of the effective number of plates in the column.

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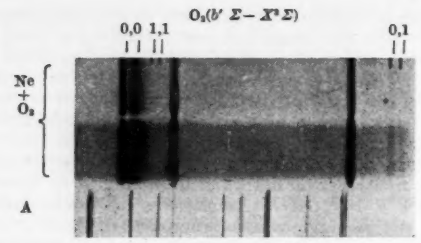
Atmospheric Oxygen Bands in Emission from Neon–Oxygen Mixtures, and in Night Sky and Auroral Luminescences

In a recent paper, Meinel[1] suggested that the radiations at 8628 A. and 8659 A. in the night sky luminescence might be identified as the R and P branches of the (0,1) band of the atmospheric oxygen system, $b^1\Sigma^+_g - X^3\Sigma^-_g$. Other bands of this system might also be present, and the absence of the most intense band, the (0,0) band, was accounted for by the reabsorption in the lower atmosphere.

This oxygen band system, best studied in absorption, has in the past few years been observed in emission by several investigators[2–4]. In spite of this, wave-length data of band heads and approximate origins are somewhat scarce and relative intensities are not given at all. More information about them is therefore needed.

In the emission from discharges through pure oxygen and neon–oxygen mixtures, I have observed three bands of the system. The (0,0) band at 7592·5, 7622·5 A. (R head and approximate beginning of the P branch, as measured from my plates) was by far the most intense. Exposure times of less than 5 sec. were sufficient to produce a suitable photographic density of the band (on unsensitized Eastman *I N* plates with a *B* II spectrograph from the Société Générale d'Optique). The two other bands observed were the (1,1) band at 7680 (partly masked), 7710·5 A. and the (0,1) band at 8604·2, 8649·8 A. with intensities of about 0·5 and 2 per cent respectively of that of the (0,0) band.

The discharges were successfully run both by ordinary high tension (50 c./s.) between cold electrodes in the discharge tube and by high-frequency tension (2 Mc./s.) between external electrodes. (In the latter case the emission had a silver-white appearance due to a strong and very even continuum extending throughout the whole region investigated, 3200–



0·02 per cent oxygen in neon. Total pressure, 700 mm. mercury. High-frequency excitation

9700 A.) Variation of total pressure and oxygen concentration did not appreciably influence the relative intensities of the bands, whereas the absolute intensities varied considerably.

This variability of the band intensities gives some information on the collision deactivation probability of the metastable $O_2(b^1\Sigma)$ state. A method similar to that used in the investigation of the metastable O I(^1S) state[5] was adopted. Preliminary results seem to indicate that the sensitivity against non-radiative deactivation of the lowest two vibrational levels in the $O_2(b^1\Sigma)$ state is slightly less than that of the O I(^1S) state.

The mean life-times of the molecular[6] and atomic metastable states here mentioned are of the same order of magnitude. The collision deactivation of the two states under similar conditions should therefore, according to the preliminary result, also be of about equal magnitude. Bearing in mind that in the upper-atmosphere oxygen atoms, excited to the $2s^22p^4\ ^1S$ state, are left undisturbed long enough to be deactivated by radiation, there is reason to believe that this should also apply to the $O_2(b^1\Sigma)$ state, provided oxygen molecules exist there. Evidence of this, however, has recently been supplied by the discovery of O_2^+ bands in the auroral spectrum[7]. Meinel's identification of atmospheric oxygen bands in the night sky luminescence seems, therefore, highly probable.

The similar behaviour of the two metastable states also indicates that the atmospheric oxygen bands might be present in the auroral spectrum with appreciable intensity. There is some experimental evidence in favour of this. On the infra-red auroral spectrogram obtained by Meinel[8], an unidentified radiation with short wave-length limit just above 8600 A. fits very well with the R head of the (0,1) band. The P branch is partly overlapped by the $N_2\,1P(2,1)$. The sharp short wave-length side of the $N_2\,1P(2,0)$ band may be due to overlapping of the R branch of the molecular oxygen atmospheric (1,1) band. But here the absorption of the (0,0) band of the same system sets in, which may result in a similar effect.

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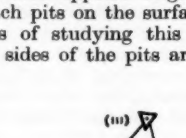
Effect of Orientation on the Metallic Reflexion of Polarized Light

E. C. W. Perryman and Miss J. M. Lack[1] have attributed the optical anisotropy of etched monel, which is face-centred cubic and should be optically isotropic, to the presence of a surface structure. They find, however, that optically anisotropic cadmium does not possess a similar structure.

By studying the reflexion of polarized light under crossed nicols from grains of known orientation, we have obtained information concerning the nature of three different types of anisotropic reflexion. These are exemplified by reflexions from surfaces of etched monel metal, isotropic aluminium the surface of which has been etched to develop cubic etch pits, and unetched anisotropic beryllium. A Bausch and Lomb elliptical vibration compensator[2] was used under a rotating stage to measure the change of phase and the rotation of the reflected polarized light.

It is well known that plane-polarized light is not affected by reflexion from an inclined polished plane if the plane of vibration is parallel or perpendicular to the axis of tilt. If these conditions are not met, the reflected light is no longer plane-polarized and can be observed under crossed nicols. Thus, when a scratch is parallel or at right angles to the plane of vibration, the scratch extinguishes the light. At intermediate positions, the scratch appears bright. The inclined faces of cubic etch pits on the surface of aluminium furnish a means of studying this 'scratch effect'. When the three sides of the pits are approximately



Large-grain aluminium specimens were etched to develop cubic etch pits. Those with orientations below the solid line showed extinction when the plane of the cube pole closest to the horizontal agreed with or was perpendicular to the plane of vibration of the light

parallel and perpendicular to the plane of vibration of the incident light, the grain will show extinction. This has been experimentally verified for all orientations below the solid line of the diagram. However, since the etch pits are not all true planar surfaces, the amount of rotation and phase change created is not constant and cannot be determined experimentally.

Grain growth studies of monel[3] have shown that a crystallographically straight interface, or the straight part of a jagged interface, is evidence of the presence of a spinel twin relationship. When traces of the four (111) planes of a grain have been plotted, the orientation can be uniquely determined. By this means, the orientations of most of the grains in several fields (× 250) were determined. By repolishing and re-etching, it was found that whereas the maximum intensity from an individual orientation might vary, the position of extinction with respect to the plane of vibration of the light remained the same, that is, extinction was reproducible.

A study of the interference figure and a correlation of the orientation with measurable rotations and phase changes[4] indicated that the anisotropy was due to the presence of a uniaxial crystal on the surface of the metal, the c-axis and therefore the extinction position of which always lay within 1·5° of the plane containing a cube pole of the monel. The inclination of the c-axis to the specimen surface within this plane was also that of the cube pole, that is, minimum intensity of reflexion when the c-axis is vertical and maximum when it is horizontal. By polishing electrolytically, and using the etching solution as the electrolyte, the thickness of this film, as well as the measurable rotation and phase change, can be increased appreciably without removing the orientation relationship. A chemical spot test showed the increased presence of a chromate. The anisotropy of etched monel is therefore attributed to a layer of hexagonal copper chromate. We feel that the fact that the minute etch pits and troughs, observed on the surface of monel by Perryman and Lack, can be compensated for as to phase change and rotation, must mean that their faces are crystallographically quite planar.

Single-grain specimens of hexagonal beryllium, which is optically active after mechanical or electrolytic polishing, show a reproducibility of extinction position[3]. In this case, there is extinction within a range of $\pm 2°$ when the intersection of the basal plane with the surface of the specimen is parallel or perpendicular to the plane of vibration of the incident light, regardless of the method of polishing. As the specimen is rotated through 360° from the extinction position, two symmetrical sets of unequal peaks are observed. The intensities of any two successive peaks are at a maximum when the basal plane is perpendicular to the surface, and a minimum when it is parallel. The graph of the measured angle of rotation of the plane of polarization versus the angle of inclination of the basal plane is linear and when extrapolated becomes 0 at 0° inclination; that is, there is no rotation when the basal plane is parallel to the surface.

The measurable anisotropy varies with temperature and on exposure to oxygen. This effect is attributed to the time-dependent development of a 'chemi-sorbed' layer at the beryllium – beryllium oxide interface[3].

Metallographically, it is of interest to note that the extinction position, in all cases studied, is reproducible and bears a definite relationship to the orientation of the grain under observation. When several orientations are prepared in a similar manner, as in a polycrystalline aggregate, the relative maximum intensities of the grains are a function of the orientation.

This work was carried out at the M.I.T. Metallurgical Project under Contract No. AT—(30-1)—981 with the U.S. Atomic Energy Commission and the U.S. National Bureau of Standards.

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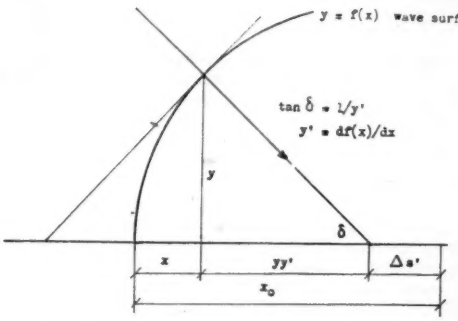
A Formula for determining the Wave-Surface if the Spherical Aberrations are Known

If the spherical aberrations of a cylindrical symmetrical optical system are known in the form of a series:

$$\Delta S' = a \tan^2\delta + b \tan^4\delta + c \tan^6\delta + \ldots, \quad (1)$$

it is possible to deduce the equation of the orthotomic wave-surfaces to the rays defined by (1), as has been shown by Picht[1]. Picht gives a recursion formula proceeding from the higher terms to the lower, which is very inconvenient if the constants $a, b, c, \ldots$ increase rapidly, as is ordinarily the case. It is possible, however, to obtain a recursion formula proceeding from the lower terms to the higher, which has been found very useful for practical purposes while analysing the concentration of light near the geometrical focus[2] by the Debye–Picht method.



From the accompanying diagram we obtain the relation

$$x_0 = x + yy' + \Delta S', \quad (2)$$

which gives the differential equation of the wave surfaces:

$$yy' + \frac{a}{y^{12}} + \frac{b}{y^{14}} + \frac{c}{y^{16}} + \ldots x - x_0 = 0. \quad (3)$$

This can easily be solved by a Legendre transformation, and by introducing the unknown variable in the transformed equation in the form of a series of the powers of the parameter $\tan^2\delta$ and determining the constants by putting the sum of them for each power equal to zero. In this way we get the meridional co-ordinates of the wave surfaces:

$$x_0 = -A \tan^2\delta - 3B \tan^4\delta - 5C \tan^6\delta \ldots \quad (4)$$

$$y = -2A \tan\delta - 4B \tan^3\delta - 6C \tan^5\delta \ldots \quad (5)$$

with the recursion for the constants:

$$A = -\frac{x_0}{2}; \; B = \frac{a-A}{4}; \; C = \frac{b-3B}{6}; \; D = \frac{c-5C}{8}. \quad (6)$$

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Compressibilities of Cubic Crystalline Powders: a New Method of Measurement

By suitable averaging, the following relations may be derived for polycrystalline aggregates consisting of randomly oriented and ideally closely packed particles of any substance crystallizing in the cubic system:

$$C'_{11} = \frac{3}{5} C_{11} + \frac{2}{5} (C_{12} + 2C_{44});$$

$$C'_{44} = \frac{3}{5} C_{44} + \frac{1}{5} (C_{11} - C_{12}).$$

C'_{11} and C'_{44} are the thickness and shear elastic constants of a plate of the aggregate and C_{11}, C_{12} and C_{44} are the elastic constants of the corresponding single crystal. If the crystal is such that the Cauchy relation $C_{12} = C_{44}$ holds good, the above equations become dependent on one another and reduce to $C'_{11} = 3C'_{44} = \frac{3}{5}(C_{11} + 2C_{12})$. If $C_{12} \neq C_{44}$, they remain independent but may be combined to give $3C'_{11} - 4C'_{44} = C_{11} + 2C_{12}$. Thus, the measurement of C'_{11} and C'_{44} will enable us not only to state whether the Cauchy relation holds good for the crystal under investigation, but also to evaluate the bulk modulus K, which is $\frac{1}{3}(C_{11} + 2C_{12})$.

C'_{11} and C'_{44} can be conveniently measured by the ultrasonic wedge method, developed and described by us in earlier publications[1]. Results obtained for a few test cases, using cubic crystal powders, compressed into plates of suitable dimensions, are given in the accompanying table in units of 10^{11} dynes per cm.^{2}.

Substance	C'_{11}	C'_{44}	$K = \frac{5}{9} C'_{11}$	K (direct measurement)
KCl	3·16	1·07	1·76	1·77
KBr	2·71	0·91	1·51	1·50
KI	2·19	0·76	1·22	1·17
NaCl	4·37	1·47	2·43	2·40

C'_{11} in all cases is three times C'_{44}. This is in conformity with the known fact that the Cauchy relation holds in all these crystals. Moreover, K obtained from C'_{11} (column 4) agrees well with the value available in the literature for each case (column 5).

It is proposed to extend this method to as many aggregates as possible, and the results will be published elsewhere.

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Reaction between Glucose and the Terminal Amino Group of Lysine

Patton and Chism[1] have recently used paper chromatography followed by examination of the unheated papers under an ultra-violet lamp for demonstrating a series of fluorescent products in boiled glucose–glycine solutions. We have been using a similar technique in an investigation of the reaction between glucose and α-N-acetyl-L-lysine at 37° C. and have found it particularly effective when combined with a study of the effect of water content on the course of the reaction.

Freeze-dried mixtures of the two substances (1½ moles glucose/amino group, *p*H on re-solution 6·5) were shown to react with progressively increasing complexity as the relative humidity increased, until at about 60 per cent relative humidity all the changes characteristic of the Maillard reaction in true solution[2] were occurring. The reaction products were examined by descending paper chromatography with 80 per cent aqueous propanol as solvent.

At 20 per cent relative humidity a simple one-to-one glucose–amino combination took place and gave rise to a spot at R_F 0·1 (*A*) which had all the properties described by Gottschalk and Partridge[3]. Glucose and α-N-acetyl-L-lysine were clearly separated at R_F 0·3 and 0·2. At 30 per cent relative humidity there appeared, in a characteristic band on the rear edge of the first spot, a second compound (*B*) which gave a bright purple fluorescence under an ultra-violet lamp and on elution showed a pronounced absorption peak at 2880 A. Reduction of ammoniacal silver nitrate and ferricyanide at *p*H 5 occurred in the area *AB*. At 40 per cent relative humidity a series of non-reducing pale-blue-fluorescent compounds (*C*) appeared at R_F's 0·05, 0·03 and 0·01, while brown products (*D*), which had now begun to accompany the reaction, remained stationary. Compounds *C* and *D* could be reproduced by storing the isolated amino–glucose complex *A* at 40 per cent relative humidity, and this, combined with a progressive movement towards the visible region of a poorly defined peak in their absorption spectra (reaching 3280 A. in the brown compounds), suggests that they are successive degradation products of the complex.

At 60 per cent relative humidity the pattern of the fluorescent compounds, though similar, was more complex and has not yet been examined in detail. It is interesting to note, however, that several of the complex effects, including browning, fall in *p*H and loss of glucose in excess of the one-to-one relationship, reached a maximum at this humidity, whereas the maximum rate of loss of amino groups occurs at 40 per cent relative humidity. A similar behaviour has already been observed in the protein–sugar reaction[4].

The precise chemical nature of compounds *A* and *B* still remains to be determined. Both appear to be primary products of a one-to-one reaction, but neither liberates glucose on acid hydrolysis nor undergoes reduction by hydrogen and palladium black at room temperature and pressure. There is therefore as yet no direct evidence for an N-glycoside or *iso*glucosamine structure of the type well known in the aromatic series. Compound *A* appears to be one of the main intermediaries in the browning sequence; but sufficient browning to account for that of the intact systems could only be achieved by storage of *A* with all the slower-moving compounds (except *D*). This mixture browned two or three times as rapidly as *A* alone. At least one of these other compounds is therefore also involved, possibly in a catalytic role, since only *A* browns when a developed paper chromatogram is heated.

These experiments, and others with a preparation of polylysine of molecular weight 10–15,000, were carried out with the object of assessing the extent of the contribution of the terminal amino groups of

lysine to the effects already observed with intact proteins[4,5]. Similar effects were observed in all three systems[6], confirming the view that the free amino groups of the protein are of great importance in the protein – sugar reaction. Even insolubility, preceded by an increase of molecular weight, occurred in the polylysine experiments, showing that cross-linking can apparently occur without the participation of other amino-acid residues.

This work was carried out as part of the programme of the Food Investigation Organization of the Department of Scientific and Industrial Research. A full account will be published elsewhere.

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Amino-acids of Silk Sericin

The silk thread extruded by the lava of the silk moth of commerce (*Bombyx mori*) consists of two parts: a central core of two filaments of the protein fibre 'fibroin', surrounded and cemented together by a layer of protein material called 'sericin'.

Analyses of the amino-acids of sericin are widely scattered through the literature[1–4], and are in no case claimed to be complete. By the methods of paper-partition chromatography we have examined the amino-acid constitution of sericin, and demonstrated the presence of fifteen amino-acids. Of these, valine had not previously been reported, and the evidence for a number of others, especially lysine, proline, glycine and phenyl alanine, was very slight.

The sericin was divided into three fractions, depending on their solubility in hot water, or in dilute acid or alkali. This separation follows the general lines described by various earlier workers[4–8]. The outer, most soluble fraction, sericin *A*, had a total nitrogen content of 17·2 per cent; paper chromatography of the hydrochloric acid hydrolysate of this fraction showed it to contain the following amino-acids: serine, threonine, glycine and aspartic acid in high concentration; glutamic acid, arginine, alanine, leucine, *iso*leucine, valine and tyrosine in moderate concentration; and lysine and phenyl alanine in relatively low concentration.

The second fraction, sericin *B*, had a nitrogen content of 16·8 per cent. On acid hydrolysis it yielded the amino-acids of sericin *A* in similar proportions, and in addition some tryptophane.

The third, inner layer of sericin, sericin *C*, adjacent to the fibroin, was insoluble in hot water, but could be removed from fibroin by treatment with hot dilute acid or alkali. Its nitrogen content was 16·6 per cent and on hydrolysis it yielded proline in addition to the amino-acids of sericin *B*. This inner layer also contained sulphur, present as inorganic sulphide. No sulphur-containing amino-acids could be detected.

There was some evidence for the presence of traces of a third basic amino-acid residue in each of the three sericin fractions. This was not histidine, for although histidine has been reported as present in sericin by other workers we could not detect it in any of the hydrolysates by the sensitive Pauly reaction[9]. The spot we obtained may have been due to hydroxylysine; but our evidence regarding this amino-acid was by no means conclusive.

The distribution of the amino-acids in sericin is being investigated by Sanger's technique[10] and by other methods.

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Preparation of the Specific Purified Antigen of Canine Hepatitis Virus and Anti-serum for Serological Studies

The natural history of mammalian hepatitides viruses supports the concept of a widespread unapparent infection[1,2] which makes it extremely difficult to study the problem by experimental inoculations without a reliable serological test. This communication describes a simple method for the purification and concentration (if necessary) of the antigen, as well as the preparation of the active anti-serum for serological studies. Four strains of the virus have been used in these experiments: two English strains, one from Australia and one from Sweden.

Preparation of antigen. Methanol cooled to −30° C. was cautiously added to a final concentration of 30 per cent to a cooled fine 10 per cent suspension of a virus-rich tissue in distilled water or to undiluted body fluid (such as serum, peritoneal fluid, etc.), while it was kept in an ice box. The resultant turbid fluid was held at 0° C. for 2–3 hr. and then centrifuged at 4,000 r.p.m. until all the suspended particles were thrown down. The supernatant fluid was removed and the sediment was taken up in a volume of 0·85 per cent saline at *p*H 6·8–7·0 equal (or less, if desired) to that of the original liquid, and after stirring thoroughly it was allowed to stand for 24 hr. at 0° C. Any undissolved material was then removed by centrifugation and the final water-clear supernatant was used as the antigen. Ethanol or butanol can be used instead of methanol, but the resultant antigens appeared to be less active.

Preparation of antiserum. Dogs were hyper-immunized with a fine 10 per cent suspension (in 0·85 per cent saline) of the virus-rich liver. The intravenous or subcutaneous inoculations of the material used were carried out by giving increasing amounts (1 to 11 ml.) of the suspension over a period of three weeks. In the intraperitoneal method three injections were given (5 ml. each) at weekly intervals.

Complement-fixation test. The test mixtures: serum (or dilution) 0·1 ml., antigen (or dilution) 0·1 ml., and complement dilution 0·5 ml. 0·85 per cent saline was always added to make the total volume 1·5 ml. Each reaction mixture was given primary incubation either in a water-bath at 37° C. for 30 min., or in a refrigerator at 3° C. for 16–18 hr., followed by 1 hr. at room temperature. Then 0·5 ml. of hæmolytic system (5 M.H.D. of hæmolytic amboceptor in a volume of 3 per cent sheep red cells suspended in 0·85 per cent saline) was added. This was followed by a final incubation in a water-bath at 37° C. for 30 min. The amount of hæmolysis was estimated in six grades. Before conducting the main test, complement was always titrated in amounts varying by 0·25 M.H.D.

Ring precipitin test. This was carried out by carefully stratifying 0·04 ml. of the viral antigen on 0·04 ml. of test serum in a small test-tube (3 mm. × 25 mm.). The reaction was allowed to stand 2 hr. at 37° C. Definite ring-like precipitate formed at the junction of the two fluids in positive cases.

Quantitative flocculation test. Dilutions of sera and antigen were prepared separately. Each dilution of test serum was set up in as many test-tubes (0·5 ml. in each) as the number of antigen dilutions required to be tested. Then 0·5 ml. of antigen dilution was added into each tube, thus doubling dilutions of both components. Readings were made after the reaction was allowed to stand 18 hr. at 37° C. A definite turbidity noticeable by the naked eye in the daylight appeared in positive tests.

Some properties of the antigen. It can be derived from various virus-rich dog tissues and body fluids, although the lungs and spleen contain less of the antigenic material. It is stable on storage at + 3° and −30° C., as well as to heating at 56° C. for 30 min. and 1 hr. The supernatant fluid after high-speed centrifugation at 15,000 r.p.m. is antigenically active. Solubility of the active material in organic solvents (benzene, chloroform, petroleum ether, ethyl ether, amyl and butyl acetate) is negligible. The antigen on being inoculated into dogs can induce the specific and sometimes fatal disease. Precipitins and complement-fixing antibodies can disappear completely from the circulating blood after one year and in some cases even earlier. At the same time these dogs appeared to be actively immune to subsequent challenge with the virus.

I am grateful to Dr. H. P. Chu for his kindness in carrying out the high-speed centrifugation, and to Mr. W. G. Orbell for technical assistance. The details of this work will be published elsewhere.

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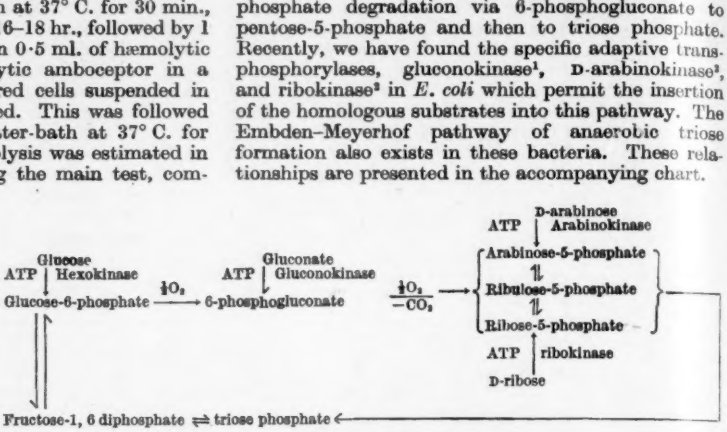
Utilization of Gluconate and Glucose in Growing and Virus-infected *Escherichia coli*

We have described various enzymes in *E. coli* participating in an oxidative pathway of glucose-6-phosphate degradation via 6-phosphogluconate to pentose-5-phosphate and then to triose phosphate. Recently, we have found the specific adaptive transphosphorylases, gluconokinase[1], D-arabinokinase[2], and ribokinase[2] in *E. coli* which permit the insertion of the homologous substrates into this pathway. The Embden–Meyerhof pathway of anaerobic triose formation also exists in these bacteria. These relationships are presented in the accompanying chart.



Alternate pathways for triose phosphate formation

The reaction of glucose-6-phosphate to 6-phosphogluconate has been considered to be essentially irreversible. If this were true, the metabolism of gluconate, for example, could only proceed via the oxidative pathway. To test this, we have measured the liberation of carbon dioxide from the C_1 of gluconate, labelled specifically in that position with carbon-14. *E. coli*, strain *B*, were grown aerobically in Warburg vessels in a mineral medium with gluconate as the sole carbon source. The carbon dioxide was trapped in sodium hydroxide and recovered quantitatively as barium carbonate in the presence of 150 micromoles of diluting sodium carbonate. The radioactivity of the barium carbonate was measured.

During growth on gluconate, the average production of carbon dioxide was 2·3 moles per mole of gluconate. The average recovery of C_1 in carbon dioxide was 88 per cent, recoveries ranging between 84 and 95 per cent. When gluconate was oxidized without growth by pre-adapted bacteria in a 0·05 *M* phosphate buffer at *p*H 7·0, carbon dioxide production was 3·5 moles per mole of gluconate and C_1 recovery was 100 per cent.

Pre-adapted bacteria were infected with about five bacteriophage *T2r*+ particles per cell in the presence of labelled gluconate, and C_1 yields were compared with those from uninfected bacteria. Although infected bacteria stopped multiplying, their respiratory quotient and rate of production of carbon dioxide were identical with those of uninfected bacteria. The C_1 recoveries from the two systems were essentially identical and almost quantitative. We conclude from these experiments that the path of gluconate metabolism in growing and virus-infected *E. coli* is almost completely, if not completely, through pentose phosphate, with attendant C_1 liberation as carbon dioxide. Furthermore, the glucose-6-phosphate oxidation to 6-phosphogluconate is essentially irreversible in these bacteria.

The same technique was applied in analysing the routes of glucose utilization by these bacteria. When glucose is converted to triose phosphate via the Embden–Meyerhof scheme, the carboxyl of pyruvate

derived from it would contain C_3 or C_4 of the original glucose. Carbon dioxide from this pyruvate might arise from a variety of pathways, two extreme cases being (1) the complete combustion of pyruvate in the tricarboxylic acid cycle, or (2) the preferential liberation of carbon dioxide from the carboxyl. No mechanism is known at present which would give rise preferentially to carbon dioxide from pyruvate $-CH_3$, which would contain the original C_1 of glucose. In the first case, we would obtain the maximal C_1 liberation as carbon dioxide and the recovery of C_1 in the carbon dioxide would be proportional to the yield of carbon dioxide from glucose.

When C_1-labelled glucose is oxidized by the bacteria in a 0·05 *M* phosphate buffer (*p*H 7·0) free of a nitrogen source, 3·2 moles of carbon dioxide were liberated per mole of glucose. This carbon dioxide contained 54 per cent of the total C_1. Since the specific activity per mgm. carbon of this carbon dioxide was that of the entire glucose, these oxidizing cells gave no indication of a preferential liberation of carbon dioxide from C_1 or of a use of the oxidative pathway.

Under conditions of growth, in which 1·4 moles of carbon dioxide were liberated per mole of glucose, a maximal value of 23 per cent (1·4/6 × 100) could be expected from the combustion of a portion of the pyruvate formed anaerobically. However, an average of 37 per cent (34–39) of the C_1 was recovered in the carbon dioxide in eight experiments. This is significantly in excess of the maximal value of 23 per cent, and the minimal value for glucose degradation by the oxidative pathway would then be 37 − 23, or 14 per cent. The maximal value would be the C_1 recovery or 37 per cent. In either case, the oxidative pathway could be supplying all the ribose requirements of the organism.

C_1 Recovery in Carbon Dioxide Produced During Glucose Utilization by *E. coli*

Physiological condition	Moles CO_2 / Mol. glucose	$BaCO_3$ (counts/min./mgm. C)	Recovery of C_1 in CO_2 (per cent)*	Theoretical C_1 recovery (per cent)	Excess (per cent)
Oxidation, no growth	3·22	212	54·4	53·7	0·7
Growth	1·32	156	37·7	22·0	15·7
T2 synthesis	1·38	121	29·1	23·0	6·1

* Calculation after correction for dilution.

When these cells were infected with five bacteriophage $T2r^+$ particles per cell, they stopped growing and proceeded to the synthesis of virus components almost exclusively[3]. Although their respiratory quotient and rate of oxygen consumption were unchanged under conditions of virus infection, the excess of C_1 in the carbon dioxide was markedly decreased. A typical experiment is presented in the accompanying table. This may be interpreted as a shunt in glucose utilization from the oxidative pathway to the anaerobic pathway and occurred under conditions in which ribose nucleic acid synthesis was eliminated and deoxyribose nucleic acid synthesis was stimulated.

We have also observed that gluconate may be used readily for growth, when far more ribose nucleic acid is produced than deoxyribose nucleic acid, but is a poor substrate for virus synthesis when an increased demand for deoxyribose nucleic acid appears. These results suggest that, in glucose utilization by *E. coli*, ribose is derived mainly from the oxidative pathway, and deoxyribose may come from constituents generated most readily from the anaerobic pathway.

This work was supported by a grant from the Commonwealth Fund. I am indebted to Dr. S. Gurin of the University of Pennsylvania for C_1-labelled gluconate, and to Dr. H. S. Isbell of the National Bureau of Standards for C_1-labelled glucose.

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Cytology of the Ecotypes of Diœcious *Melandrium dioicum* (L. emend.) Coss. & Germ.

In 1942, a tetraploid ($2n = 48$) plant of the diœcious *Melandrium dioicum* complex was discovered by D. Löve[1] in a Swedish population. She diagnosed it as "*M. crassifolium* Fries"[2], which Turesson[3] has considered to be a coastal ecotype of *M. dioicum*. From herbarium studies of the morphology of adult plants, she further concluded that "*M. crassifolium*" and *M. rubrum* subsp. *lapponicum* Simm.[4] are synonymous and, as the latter has been regarded by Turesson[3] as forming part of the sub-alpine ecotype of *M. dioicum*, this means that there is no outstanding morphological difference between the 'coastal' and 'sub-alpine' ecotypes of this species. From a comparison of pollen-sizes in her tetraploid and these ecotypes, she concluded that both the coastal and sub-alpine races are tetraploid.

This is important, because it had already been established (in 1940) by Warmke and Blakeslee[5] that a tetraploid race, once formed, could spread without loss of diœcism even though such a race had not then been discovered. Nevertheless, Baker[6–8] has shown that a number of plants representing the coastal ecotype in the Shetland Isles are diploid ($2n = 24$) without any tetraploids being found, despite the fact that this race shows many morphological features normally associated with polyploidy (and even found in artificial polyploids in this genus[5,9]), such as increased flower-, capsule- and seed-size along with thicker and hairier leaves and stems. It was pointed out[6,8] that further evidence that all coastal and sub-alpine plants are not tetraploid had been provided by the determination of diploidy in sub-alpine material collected by Dr. J. Clausen at Abisko (in Swedish Lappland) and examined by Warmke and Blakeslee[5].

Recently, we have been able to study material collected by one of us (H. G. B.) in 1950 at Krossbu (alt. 1,340 m.) and Finse (alt. 1,500 m.), in Norway, the latter station being the type locality of Turesson's alpine ecotype of this species[3]. In addition to this sub-alpine and alpine Norwegian material, plants collected by Miss E. A. Baker, at a height of approximately 1,500 m. on the Weissenstein in Switzerland, have been grown and examined. All these thick-leaved plants (of both 'sexes') gave a diploid count with the usual complements of sex-chromo-

somes and autosomes. Their crossing reactions with each other and with British material are being examined; but all indications, so far, are that they do truly represent ecotypes of the single species *M. dioicum*. Therefore, it appears that Löve's tetraploid plant is not characteristic of the coastal and montane races of this species (which have remained at the diploid level), but is an aberrant. It would have been most interesting if the fate of this plant, representing a potential new race, could have been followed in Nature.

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Unusual Features of the Root System of the Oil Palm in West Africa

On the deep acid sands of West Africa the roots of the oil palm (*Elæis guineensis*) may be divided into primary, secondary, tertiary and quaternary.

The primary roots emerge radially from the trunk-base and proceed for long distances without change in diameter. In palms over two years old this diameter is very constant (about 5 mm.). No roots have been found emerging at less than 15° from the soil surface. After proceeding downwards to a depth proportional to the angle they make with the soil surface, these primary roots tend to level out and travel horizontally for considerable distances (specimens from a 12-ft. palm have been traced for more than 40 ft. without coming to the end). They are completely unbranched and, in this soil, which is very free from obstructions, travel almost straight, occasionally tending to rise slightly. All primary roots found have been at a depth of more than 18 in.

The secondary roots emerge from the primary root within 45° of the vertical diameter, the sides of the primary roots being almost entirely clear. Of these secondary roots approximately 70 per cent grow vertically upwards and the remaining 30 per cent vertically downwards. The roots that grow upwards continue until they reach the soil surface, those growing downwards being of variable length.

The tertiary roots, which are probably the main absorbing roots, emerge at right angles from the secondary roots and travel in a horizontal plane. Their length is normally limited to about 10 cm., and the majority of them occur in the upper 10 cm. of the soil, where their length is also greatest. They do not occur in quite the same way on secondary roots growing downwards, as the tertiary roots tend also to continue downwards, producing an effect more like an unequal dichotomy.

The quaternary roots are very short (normally less than 5 mm.) and emerge at right angles to the tertiary roots.

Two other features of interest were noted: (1) The root system undergoes constant renovation, new primary roots emerging from the trunk base and old roots dying back from the tips. (2) New roots tend to grow along old dead roots. Whether the reason for this is nutrition or ease of spread remains to be proved by future experiments.

The importance of this type of root system to plantation practice is manifold. Thus mineral fertilizers do not need to be buried to become available to the plant, and, in fact, are likely to be more quickly and certainly absorbed if applied to the surface of the soil. Again, mechanical cultivation between the rows with implements such as disk harrows will do very little damage to roots, as the numbers of roots other than tertiary ones that will be cut will be very small.

My thanks are due to Messrs. Pamol, Limited, under whose auspices this work was done, for permission to publish this note.

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Sapele, Nigeria. Sept. 12.

Effect of Nitrogen-fixing Blue-Green Algæ on the Growth of Rice Plants

The fixation of atmospheric nitrogen by blue-green algæ has been reported by Pringsheim, Molisch, Drewes, Allison and Morris, De, Stokes, Bortels, Fogg, Burris and Wilson, Shioiri and Nishigaki *et al.*[1]; but no experiments on the effect of these algæ on the growth of rice plants have been performed.

About ten years ago one of us[2] began collecting blue-green algæ from the rice fields in various Far Eastern and South Sea regions. In the 643 samples collected, only thirteen blue-green species proved to be able to fix atmospheric nitrogen. These thirteen algæ grow abundantly in the tropical and semi-tropical regions of Java, Sumatra, Borneo, the Philippine Islands, Malaya, Indo-China, Siam, Burma, Hainan, Formosa and South China; but they are scanty in Japan, North China, Manchuria, Korea and Sakhalin. They belong to the genera *Tolypothrix*, *Nostoc*, *Schizothrix*, *Calothrix*, *Anabænopsis* and *Plectonema*. *Tolypothrix tenuis* (from Borneo), *Calothrix brevissima* (from Palau Islands), *Anabænopsis* sp. (from Sumatra) and *Nostoc* sp. (from Java) were the only ones of which bacteria-free cultures were obtained in a nitrogen-free medium (0·3 gm. K_2HPO_4, 0·2 gm. $MgSO_4 . 7H_2O$, 0·05 gm. $CaCl_2$, a trace of $FeCl_3$, 2 gm. glucose, and 1,000 c.c. distilled water). The total nitrogen fixed in 2 months was 9·6 mgm. in *Tolypothrix tenuis*, 5·2 mgm. in *Calothrix brevissima*, 3·4 mgm. in *Anabænopsis* sp. and 3·1 mgm. in *Nostoc* sp., estimated by the micro-Kjeldahl method.

With the help of such pure cultures the effect of these algæ on the growth of rice plants was examined

Table 1

Experiment	Length of leaves (cm.)			
	Tolypothrix tenuis	*Calothrix brevissima*	*Anabænopsis* sp.	Control
1	75·5	78·5	70·5	72·5
2	78·5	84·0	76·0	68·5
3	80·5	80·5	75·5	72·5
4	84·0	80·5	78·0	74·0
5	80·5	82·0	78·0	76·0
6	80·0	85·0	80·5	71·0
Mean	81·33	81·75	76·42	72·42
Variance	19·72	4·90	9·61	5·43
Standard deviation	4·44	2·21	3·10	2·33

in water-, as well as in pot-cultures[3,4], and in paddy-field experiments[5]. In the water-cultures with *Tolypothrix tenuis* the lengths of the leaves increased on an average by 17 per cent and the number of ears by 30 per cent. In pot-cultures with three of the blue-green algæ the effect on the lengths of the leaves is shown in Table 1.

As will be seen, the presence of *Tolypothrix* had a positive effect on the growth of the plants, the amount of nitrogen absorbed by them being 7·5 lb. per acre in excess of the control and the total nitrogen fixed at about 20 lb. per acre, while *Anabænopsis* produced no appreciable effect. In the paddy-field experiment *Tolypothrix tenuis* positively affected the growth of the plants, increasing the rice yield both in well-drained, as well as in badly-drained, paddy fields (Table 2).

Table 2

	Rice harvest (bushels per acre)		Percentage increase
Well-drained paddy field	non-inoculated	44·9	15
	Tolypothrix-inoculated	51·8	
Badly-drained paddy field	non-inoculated	30·3	25
	Tolypothrix-inoculated	37·8	

Full details will be published elsewhere.

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Micro-electrode for Electro-physiological Work

The micro-electrode described by R. A. Weale[1] necessitates the use of an electronic device, just for breaking the circuit, when the chain of silver crystals has reached the tip of the capillary tube. Furthermore, the micro-electrode proper has three disadvantages: (1) contact is easily disrupted in the capillary part; (2) resistance is comparatively high; (3) the electrolyte remains between the crystals. These disadvantages are a consequence of the 'feathery' or 'larchlike' character of the chain of silver crystals, which do not adhere sufficiently to one another.

We have prepared micro-electrodes in the following way. A capillary tube is drawn out by a method described by P. de Fonbrune[2]. The following stages are exactly in accordance with the method of Weale, except that we use silver nitrate instead of water in the tube. Then a plating bath is made of a drop of saturated silver nitrate on a tissue-culture slide (hollow ground). The bath is put on the table of the microscope, the tip of the capillary brought into the drop and observed with a high-power objective. The plating circuit is closed by bringing the silver wire anode into the drop as well. With a plating current of 1 V., very slow growth of relatively large silver crystals starts. As soon as the rate of growth exceeds the limit of being just perceptible, the plating voltage is reduced with an adjustable resistance. After about fifteen minutes, a few tenths of one volt will be sufficient to maintain the slow growth. Quicker growth suddenly produces the feathery chain. The indispensable watching of the growth of the crystals is fairly trying, as they take about 45 minutes to reach the tip. When the chain is finished, we break the circuit, an electronic device thus being dispensed with.

The result is a micro-electrode which is massively filled with silver. Consequently (1) contact is secured by the crystals adhering closely; (2) the resistance averages one ohm; and (3) no electrolyte remains between the crystals.

This method holds good for electrodes not smaller than 5 μ. Smaller tubes fill spontaneously with silver crystals. This curious phenomenon unfortunately produces crystal chains of the feathery type. We have not yet succeeded in solving this problem.

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Bacterial Flagella

In a recent communication in *Nature*[1], Weibull tends to regard my theory of bacterial motility as incorrect and as based on misinterpretation of observations made with dark-field microscopy. He confuses the issue, as so many do, by assuming that 'flagella' in different groups of bacteria mean the same thing, whereas in reality they often are structures *sui generis* in the various groups and may have very little or even nothing in common[2–6].

Weibull states that motile bacteria always have flagella; this is incorrect. He refers to Kauffmann's statement that *H*-serum immobilizes motile bacteria immediately, because it 'paralyses' their flagella. But my *observations* have shown that *H*-serum produces a precipitate on bodies and flagella which, after a determined struggle on the part of the bacteria, becomes so thick that motility gets less and less[6,7]. This purely mechanical progressive inhibition can be watched in a cinemicrographic film I made[6]. Weibull also mentions Ørskow's observation that *Proteus* bacteria on agar, covered with ink, can give the impression that their bodies lie still while their flagella whirl ink particles about. Flagella, however, were not actually seen, and it must be difficult to make sure that the bodies really are motionless; in any event, my contention that normally the body wags the flagella does not imply that nothing else can ever move them. Kingma Boltjes's work, also quoted by Weibull in support of his criticism, is invalidated by confusing the flagella of the large spirillums with those of typhoid and *Proteus* bacteria.

They are in entirely different categories, as I have shown[2-4,9]. One should not (and here I also think of electron microscopists) apply conclusions drawn from observations on spirillums and vibrios to the flagella of typhoid, *Proteus* and *subtilis* bacteria. In this letter I shall try to confine myself to a discussion of the latter bacteria. Weibull also mentions Fleming's experiments on penicillin-poisoned *Proteus* bacteria. I have repeated these experiments and made a film of them and find them inconclusive. I think these grotesque movements are more readily explained by bodily contortions. If flagella could perform in this way, they would require an elaborate system of co-ordination, something like a central nervous system.

Weibull agrees with Reichert's interpretation of the mechanical function of flagella. I have often pointed out[2-4,6,7,10-12] that Reichert never saw normal flagella functioning, at least not in typhoid and *Proteus* and suchlike bacteria. He himself states that he could only make their flagella visible with his darkground technique by suspending them in a colloidal solution. He imagined that the colloid just retarded motion and had an effect on refraction; but in reality, as I have repeatedly shown, it became adsorbed on the bodies and flagella, just like *H*-serum. What Reichert studied were live artefacts. Weibull's own *Proteus* flagella, coming from an agar medium and therefore growing in a colloidal medium, during growth are also covered with a sheath of agar. Weibull evidently does not know of and underrates *sunlight* darkground microscopy. It is only with sunlight darkground microscopy that I succeeded in making *naked* flagella and tails properly visible in broth or water[2,11-14]. By this technique, one can see the naked thin tail split into numbers of very thin flagella; this is entirely different from the picture on which Reichert and Weibull have worked.

With[5] this sunlight darkground method[15] I have made further observations on the function of normal, that is, not artificially thickened, tails and their constituent flagella. There is the sudden reverse, the semi-somersault, the possibility of shaking off flagella by mechanical means after which swimming goes on undisturbed, the curious fact that the same bacterium will produce magnificent tails in one broth and none in another while motility is identical in both, and the definite spiral movement and shape of bacterial bodies (sometimes hidden by their high speed and then made visible by slow-motion filming). These studies, extending over twenty years, make it impossible for me to regard flagella as motor organs[2-16].

As a result of X-ray diffraction analysis of his flagella from *Proteus* and *subtilis* bacteria, Weibull places their proteins in the fibrous protein group, which comprises keratin and myosin. Chemical analysis gave him a low cystine and a high lysine content. This would fit in much better with myosin than with keratin. But chemical analysis of flagella from typhoid bacteria undertaken in my Department showed high cystine and low lysine content[17]. This would place flagella in the keratin group. I find it difficult not to consider that perhaps we are all analysing our respective nutrient media and not so much the flagella.

Weibull says the source of energy of flagella is obscure. This is not the only obscurity. Supporters of the motor theory of bacterial flagella do not commit themselves readily as to the origin of flagella. If they start in the protoplasm they must pierce the cell wall. In the case of peritrichous bacteria such as *Proteus*, this would mean dozens of holes. When are the new holes made, before or after cell division? After piercing the wall, the flagella must bend at right angles, run along the cell wall in close apposition, and at the end of the bacterium they must twist round one another to form a tail, which performs spiral movement. The mechanical implications of such an arrangement are extraordinary, and sudden reverses and semi-somersaults must cause awkward complications. If, on the other hand, the flagella arise outside the cell wall and yet are active motor organs, it follows that bacteria must have live active protoplasm both outside and inside the cell wall. These two masses of protoplasm evidently cannot directly communicate with one another and this creates an entirely novel situation in biology. The mechanical implications here are too formidable. My theory at least does away with difficulties of this kind. I do not claim that it is the last word on bacterial motility.

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[10] Pijper, A., *Z. Bakt., I, Orig.*, **118**, 113 (1930).
[11] Pijper, A., *Z. Bakt., I, Orig.*, **123**, 195 (1931–32).
[12] Pijper, A., *J. Biol. Phot. Assoc.*, **8**, 158 (1940).
[13] Pijper, A., a motion picture of bacterial shape and motility (Pretoria, Wallachs, 1947).
[14] Pijper, A., *Nature*, **161**, 200 (1948).
[15] Pijper, A., *S. Afr. J. Sci.*, **46**, 296 (1950).
[16] Pijper, A., *J. Bact.*, **53**, 257 (1947).
[17] Unpublished observations.

As any reader of Pijper's many works on bacterial flagella will soon discover, his opinions on this subject have changed considerably during the years. In the work from 1947, cited by me, bacterial flagella are described as "lifeless mucous twirls" or "polysaccharide twirls".

That the flagella of *Proteus vulgaris* are not mucous twirls or polysaccharide twirls is clear from chemical analyses and from X-ray investigations. It should suffice to mention their nitrogen content (16 per cent), and the near absence of carbohydrate (less than 0·2 per cent). From this it follows also that the *Proteus flagella*, prepared by me, are obviously not covered by a sheath of agar, as Pijper says.

As to the question of their role as motor organs, an excellent review of the different opinions on this matter is found in ref. 3. I am still convinced that the experiments of Ørskow, Kauffmann, Kingma Boltjes, Fleming, and others, carried out by independent methods, show that they are active motor organs.

Claes Weibull

Institute of Biochemistry,
University of Uppsala.

[1] Weibull, C., *Biochim. Biophys. Acta*, **3**, 379 (1949).
[2] Astbury, W. T., and Weibull, C., *Nature*, **163**, 280 (1949).
[3] "The Nature of the Bacterial Surface" (Blackwell, Oxford, 1949).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, October 29

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Discussion on "The Social Implications of Television" (to be opened by Mr. F. H. Townsend).

Tuesday, October 30

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Prof. Kathleen Lonsdale, F.R.S.: "Patterns".*

ROYAL ANTHROPOLOGICAL INSTITUTE (at 21 Bedford Square, London, W.C.1), at 5.30 p.m.—Miss Audrey I. Richards: "Tribal Admixture in Uganda".

UNIVERSITY OF LONDON (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Prof. O. Hassel: "Some Fundamental Problems in Structural Organic Chemistry and their significance to the Chemistry of Substances containing Six-Membered Rings".* (Further Lecture on October 31.)

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.30 p.m.—Prof. R. A. Peters, F.R.S.: "The Scientific Basis of Medicine, 7, Biochemical Function of Vitamin B_1".* (Further Lectures on November 2, 5, 7, 14, 16, 20, 23, 27 and 29, December 4, 6 and 11.)

SOCIETY OF INSTRUMENT TECHNOLOGY (at the Royal Society of Tropical Medicine and Hygiene, Manson House, Portland Place, London, W.1), at 6.30 p.m.—Mr. E. B. Moss: "Development of Materials for Instrument Manufacture".

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, W.1), at 7 p.m.—Dr. W. F. Hilton: "Supersonic Propellers".

Wednesday, October 31

ROYAL STATISTICAL SOCIETY, RESEARCH SECTION (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.15 p.m.—Mr. P. Armitage: "The Statistical Theory of Bacterial Mutation".

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY, SOCIAL PHILOSOPHY SECTION (at the Portico Library, Mosley Street, Manchester), at 5.30 p.m.—Mr. David K. Baxandall: "The Function of a City Art Gallery".

PHYSICAL SOCIETY, COLOUR GROUP (at the E.L.M.A. Lighting Service Bureau, 2 Savoy Hill, London, W.C.2), at 3.30 p.m.—Mr. P. Warburton: "The Appearance of Colours in Pattern Design".

Thursday, November 1

PHYSICAL SOCIETY, OPTICAL GROUP (in the Physics Department, Imperial College of Science and Technology, Imperial Institute Road, London, S.W.7), at 3 p.m.—Scientific Papers.

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Scientific Papers.

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 5.15 p.m.—Prof. E. N. da C. Andrade, F.R.S.: "The Physics of the Deformation of Metals". (Further Lectures on November 8, 15 and 22.)

PLASTICS INSTITUTE, NORTH-WESTERN SECTION (in the Great Hall, College of Technology, Manchester), at 6.30 p.m.—Prof. W. T. Astbury, F.R.S.: "Fibres and Chain-Molecules, Old and New". (Members of the Society of Dyers and Colourists are invited.)

CHEMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Scientific Papers.

Friday, November 2

PHYSICAL SOCIETY, ACOUSTICS GROUP (in the small Lecture Theatre, Science Museum, Exhibition Road, London, S.W.7), at 5 p.m.—Discussion on "The Calibration of Transducers by the Reciprocity Method" (to be opened by Mr. E. G. Butcher).

ROYAL INSTITUTE OF PHILOSOPHY (at University Hall, 14 Gordon Square, London, W.C.1), at 5.15 p.m.—Prof. C. D. Broad: "Philosophy".* (Further Lecture on November 9.)

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.30 p.m.—Prof. D. Keilin, F.R.S.: "The Scientific Basis of Medicine, 8, Metal Catalysis and Intracellular Respiration".* (Further Lectures on November 5, 7, 14, 16, 20, 23, 27 and 29, December 4, 6 and 11.)

INSTITUTION OF WORKS MANAGERS (at the Waldorf Hotel, Aldwych, London, W.C.2), at 7 p.m.—Annual General Meeting.

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Sir John Cockcroft, F.R.S.: "Experiments with High Energy Nucleons and Quanta".

Friday, November 2—Saturday, November 3

INSTITUTE OF PHYSICS, X-RAY ANALYSIS GROUP (at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2).—Conference on "The Structures of Silicate Minerals".

Saturday, November 3

ASSOCIATION OF SCIENTIFIC WORKERS, AGRICULTURAL COMMITTEE (at the Society for Visiting Scientists, 5 Old Burlington Street, London, W.1), at 3 p.m.—Sir William Slater: "The Training and Supply of Biologists".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

RESEARCH LECTURER IN APPLIED PHYSIOLOGY AND APPLIED PSYCHOLOGY in the Nuffield Department of Industrial Health—The Registrar, King's College, Newcastle-upon-Tyne (October 31).

PRINCIPAL (a good honours degree and teaching experience essential) OF THE SOUTHEND MUNICIPAL COLLEGE—The Acting Chief Education Officer, Education Office, Warrior Square, Southend-on-Sea (November 1).

CHEMIST to carry out research on building materials at the laboratory in Wimbledon—The Director of Research, Railways Executive, Research Department, London Road, Derby (November 3).

CHEMISTS at the Central Laboratory, Chiswick: (Ref. F/EV.18Ca) with experience or interest in general analytical work (excluding metallurgical analysis), (Ref. F/EV.186b) with experience or interest in technology of liquid fuels and lubricating oils—The Staff Officer, London Transport Executive, 55 Broadway, London, S.W.1, quoting the appropriate Ref. No. (November 3).

DEMONSTRATOR IN ANATOMY—The Registrar, King's College, Newcastle-upon-Tyne (November 3).

GENERATION ENGINEER (Construction), in the Eastern Division based at Divisional Headquarters in London—The Director of Establishments, British Electricity Authority, British Electricity House, Great Portland Street, London, W.1, quoting AE/212 (November 3).

HEAD OF THE DEPARTMENT OF ELECTRICAL ENGINEERING—The Registrar, Nottingham and District Technical College, Nottingham (November 3).

JUNIOR RESEARCH FELLOWSHIPS IN ORGANIC CHEMISTRY—The Clerk to the Governors, Birkbeck College, Breams Buildings, London, W.C.1 (November 3).

LECTURER IN APPLIED MATHEMATICS—The Registrar, The University, Sheffield (November 3).

LECTURER IN THE DEPARTMENT OF ELECTRICAL ENGINEERING, Oldham Municipal Technical College—The Director of Education, Education Offices, Oldham (November 3).

LECTURER (with an engineering degree and suitable industrial experience) IN THE DEPARTMENT OF MECHANICAL ENGINEERING, capable of teaching Thermodynamics and Hydraulics to students studying for the Higher National Certificate and Final B.Sc. (Engineering)—The Principal, Acton Technical College, High Street, Acton, London, W.3 (November 3).

LECTURER IN GEOLOGY—The Secretary, The University, Edinburgh (November 3).

LECTURER IN METALLURGY at the Technical College of Monmouthshire—The Director of Education, County Hall, Newport, Mon. (November 3).

LECTURERS (science graduates) IN THE DEPARTMENT OF EDUCATION—The Secretary, International Wool Secretariat, Dorland House, 18–20 Regent Street, London, S.W.1, endorsed 'Confidential' (November 3).

MINING ENGINEER to take charge of the sinking, surface workings and development of a large colliery on the South-Western Division—The Divisional Establishment Officer, National Coal Board, South-Western Division, Cambrian Buildings, Mount Stuart Square, Cardiff (November 3).

SCIENTIST (mycologist or botanist, with good honours degree or equivalent qualification, and experienced in microscopical examination of timbers) in connexion with the study of the degradation and methods of preservation of structural timbers, especially in cooling towers—The Secretary's Office (Establishments), Applications Section, British Electricity Authority, British Electricity House, Great Portland Street, London, W.1, quoting AE/210 (November 3).

LECTURER IN THE DEPARTMENT OF VETERINARY PATHOLOGY—The Registrar, The University, Liverpool (November 5).

PLANT PATHOLOGIST—The Registrar, Wye College, Wye, Ashford, Kent (November 5).

PRINCIPAL SCIENTIFIC OFFICER (Sociologist) IN THE USER REQUIREMENTS DIVISION of the Building Research Station (at present stationed in South Kensington), to undertake research into the relationship between design of buildings of all types and the requirements of their occupants—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.4084/51 (November 8).

PRINCIPAL SCIENTIFIC OFFICERS IN THE ROYAL NAVAL SCIENTIFIC SERVICE: (*a*) at the Underwater Countermeasures and Weapons Establishment, Havant—PHYSICIST with considerable experience in the development of electronic amplifiers and similar devices together with a wide experience of magnetic and electromagnetic apparatus and a thorough knowledge of eddy current phenomena in various conducting media, to lead a group of scientists engaged on the development of electric and electromagnetic devices; (*b*) at the Naval Construction Research Establishment, Rosyth—PHYSICIST able to take charge of a division carrying out applied research in connexion with underwater explosives, gun and rocket blast and the effect of these on ships' structures; (*c*) at the Naval Construction Research Establishment, Rosyth—ENGINEER familiar with modern techniques of load strain measurements and with a sound knowledge of the design and theory of structures to undertake both small- and large-scale investigations and experiments involving the mechanical testing of structural assemblies in steel—The Secretary, Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.4080/51 (November 8).

HEAD OF THE DEPARTMENT OF SCIENCE (Grade I), Reading Technical College—The Clerk to the Governors, Education Office, Blagrave Street, Reading, Berks (November 10).

ASSISTANT LECTURER IN CHEMISTRY—The Registrar, Trinity College, Dublin (November 10).

SENIOR LECTURER and a LECTURER IN THE POSTGRADUATE SCHOOL OF MINING—The Registrar, The University, Sheffield (November 10).

SENIOR SCIENTIFIC OFFICER (with an honours degree in organic chemistry and some research experience, preferably of synthetic work) IN THE BIOCHEMISTRY DEPARTMENT—The Secretary, Hannah Dairy Research Institute, Kirkhill, Ayr (November 12).

SCIENTIST I (with a good honours degree in chemistry, and have studied physics, engineering or fuel technology to degree standard, with considerable experience of research in heavy industry) to lead a team on pilot plant and associated research on carbonization, at the Central Research Laboratories, Stoke Orchard, Cheltenham—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, endorsed T7/382 (November 14).

PROFESSOR OF PHILOSOPHY, and a LECTURER (Grade I) or SENIOR LECTURER IN MATHEMATICS, at the University of Tasmania—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (November 15).

VETERINARY SURGEONS in the Field and Research branches of the Department of Veterinary Service, Southern Rhodesia—The Secretary, Southern Rhodesia Government, 429 Strand, London, W.C.2 (November 15).

LECTURER IN PATHOLOGY and an ASSISTANT LECTURER IN PHYSIOLOGY, at Makerere College (University College of East Africa)—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (November 17).

RESEARCH OFFICER (with University degree with honours in science or applied science, with physics or physical chemistry as major subject, or equivalent qualifications) IN THE DIVISION OF INDUSTRIAL CHEMISTRY, Fishermen's Bend, Melbourne, to undertake investigations on the reactions and equilibria in gasworks and/or metallurgical refractories—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 3580 (November 17).

SENIOR STATISTICIAN at the Waite Agricultural Research Institute of the University of Adelaide, to assist in the design and interpretation of the experimental programme of the Institute, and to give introductory lectures in statistical methods in the Faculty of Agricultural Science—The Registrar, The University, Adelaide, Australia (November 30).

AERONAUTICAL AND MECHANICAL ENGINEERS (Ref. Est. 5c/48) at the Ministry of Supply in London and elsewhere, for the planning and progressing or control of production or inspection of air and marine craft and ancillaries and of related machine tools, gauges and armament, AUTOMOBILE AND MECHANICAL ENGINEERS (Ref. Est.5c/49) in London and elsewhere, for the planning and progressing or control or inspection of wheeled and tracked vehicles and components, MECHANICAL ENGINEERS (Ref. Est.5c/52) in London and elsewhere, for the design and development or standardization or planning and progressing or control of production or inspection of air and marine craft and installations, wheeled and tracked vehicles, etc.—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting C.536/51AA and the appropriate Ref. No.

ASSISTANT BIOCHEMIST (B.Sc. graduate in chemistry, hons. degree desirable) IN THE DEPARTMENT OF CLINICAL PATHOLOGY—The Secretary, United Manchester Hospitals, Royal Infirmary, Manchester 13.

ASSISTANT TEACHER (with graduate or equivalent qualification) OF CHEMISTRY AND PHYSICS and related subjects, in the Department of Science, Sheffield College of Commerce and Technology—The Director of Education, Education Office, Sheffield 1.

CHEMISTS AND METALLURGISTS (Experimental Officer grade) at a Ministry of Supply research establishment in Berkshire: METALLURGIST (Ref. F.591/51A) with research experience in electrodeposition or in the investigation of the properties of metallic films and coatings, PHYSICAL CHEMIST or PHYSICIST (Ref. F.592/51A) with interest and preferably experience in work on ceramic materials—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No.

CHEMISTS (Senior Scientific Officer grade) (with a first- or second-class honours degree in chemistry or equivalent qualification, preferably with explosives or propellent experience) at Ministry of Supply London headquarters, for work concerned with guided weapons—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting F.723/51A.

ELECTRICAL ENGINEER (young university graduate, with research outlook) to join a team working on aircraft de-icing—The Employment Officer, National Research Council, Sussex Street, Ottawa, Ont., Canada.

ENGINEER at a Ministry of Supply establishment at Bickley, Kent, to be responsible for inspection of radio fuses and some development work—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting D.435/51A.

ENGINEER at a Ministry of Supply establishment in Hants, to run a 10,000 kW. gas turbine power station and control a substation with 40 M.V.A., 33 kV. grid intake and associated factory H.T. distribution—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting D.455/51A.

EXPERIMENTAL OFFICERS in various Royal Ordnance Factories: (*a*) in Somerset (SENIOR EXPERIMENTAL OFFICER, EXPERIMENTAL OFFICERS and ASSISTANT EXPERIMENTAL OFFICERS, Ref. F.724/51A) for work connected with the manufacture of explosives and acids and routine analysis of a more intricate nature, (*b*) in Ayrshire (ASSISTANT EXPERIMENTAL OFFICER, Ref. F.725/51A) for chemical analysis and experimental work, supervision of chemical testing of high explosives and related substances, (*c*) in Lancashire (EXPERIMENTAL OFFICER, Ref. F.726/51A) for laboratory work, (*d*) in the London area (ASSISTANT EXPERIMENTAL OFFICER, Ref. F.727/51A) for chemical analysis of ferrous and non-ferrous metals and alloys and works control of ferrous and non-ferrous metallurgical processes—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No.

EXPERIMENTAL OFFICERS or ASSISTANT EXPERIMENTAL OFFICERS, in the Ship Division of the National Physical Laboratory (Department of Scientific and Industrial Research), Teddington, for experimental work in the Ship Tanks—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting C.613/51A.

FISHERIES OFFICER (with a University degree in natural science, preferably zoology, and a real interest in natural history) in the Agricultural Department, Tanganyika, to investigate the potentialities of marine fishing along the coast of Tanganyika, and types and habits of fish in these waters, etc.—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting 27404/10/51.

GRADUATES IN PHYSICS or MATHEMATICS (with first- or second-class honours) as METEOROLOGISTS in Nigeria—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting Ref. No. 27118/4/51.

HEAD OF THE DEPARTMENT OF ENGINEERING AND MINING, Wakefield Technical College—The Director of Education, 27 King Street, Wakefield.

IRRIGATION ENGINEER IN THE DEPARTMENT OF WORKS AND HYDRAULICS, Trinidad—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting Ref. No. 27322/228.

JUNIOR INVESTIGATOR (with B.Sc., or equivalent, in metallurgy) for work on the welding of alloy steels—The Secretary, British Welding Association, 29 Park Crescent, London, W.1.

LECTURER (Grade I) IN COTTON SPINNING—The Principal, Technical College, Paisley.

MICROBIOLOGIST or BIOCHEMIST (postgraduate, preferably with several years research experience) to take part in research work, mainly on the mode of action of antibacterial agents—The Secretary, Wright-Fleming Institute, St. Mary's Hospital Medical School, Paddington, London, W.2.

OBSERVER (based in Trinidad) to take charge of seismological recording stations to be set up in Windward and Leeward Islands—The Under-Secretary of State, Research Department, Sanctuary Buildings, Great Smith Street, London, S.W.1.

PHYSICAL CHEMIST (degree in chemistry essential, and some research experience in electrochemistry or corrosion an advantage) for research in the Electrochemistry Section of the Laboratories at Sketty Hall, Swansea—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1.

PLANNING ENGINEER to undertake the detailed construction planning of sections of large factories and to follow up construction and installation progress—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs.

PRINCIPAL SCIENTIFIC OFFICER (with a good honours degree and some research experience) IN THE ENGINEERING DIVISION, to undertake investigation of problems associated with the mechanical harvesting, handling and processing of underwater seaweed—The Secretary, Institute of Seaweed Research, Inveresk, Midlothian.

PRINCIPAL SCIENTIFIC OFFICER (with a first- or second-class honours degree in physics; a wide general physics background is essential) at the Ministry of Supply London headquarters, for the co-ordination of physical research for guided weapons and evaluation of progress in new techniques for potential application to weapon projects—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.293/51A.

RESEARCH ASSISTANT for dissection studies on cereals—The Director of Research, Research Association of British Flour Millers, Cereals Research Station, Old London Road, St. Albans, Herts.

RESEARCH ASSISTANT to carry out experimental work on the effect of adsorption on the strength of solids, under the supervision of Dr. S. J. Gregg—The Registrar, University College, Exeter.

RESEARCH ASSISTANT (Scientific Officer grade, with appropriate honours degree, or equivalent), to take part in studies mostly concerned with use of chicks in nutritional research—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, Berks quoting 51/5.

RESEARCH OFFICER (with degree in physics, or equivalent) for work on full- or semi-scale plant, eventually to supervise technical investigations on dust and pulverizing, and a RESEARCH OFFICER (with degree in physics, or equivalent, and experience in the finer techniques of physical measurement and of electronics desirable)—The Assistant Secretary, Ref. A.4, British Coal Utilization Research Association, Randalls Road, Leatherhead, Surrey.

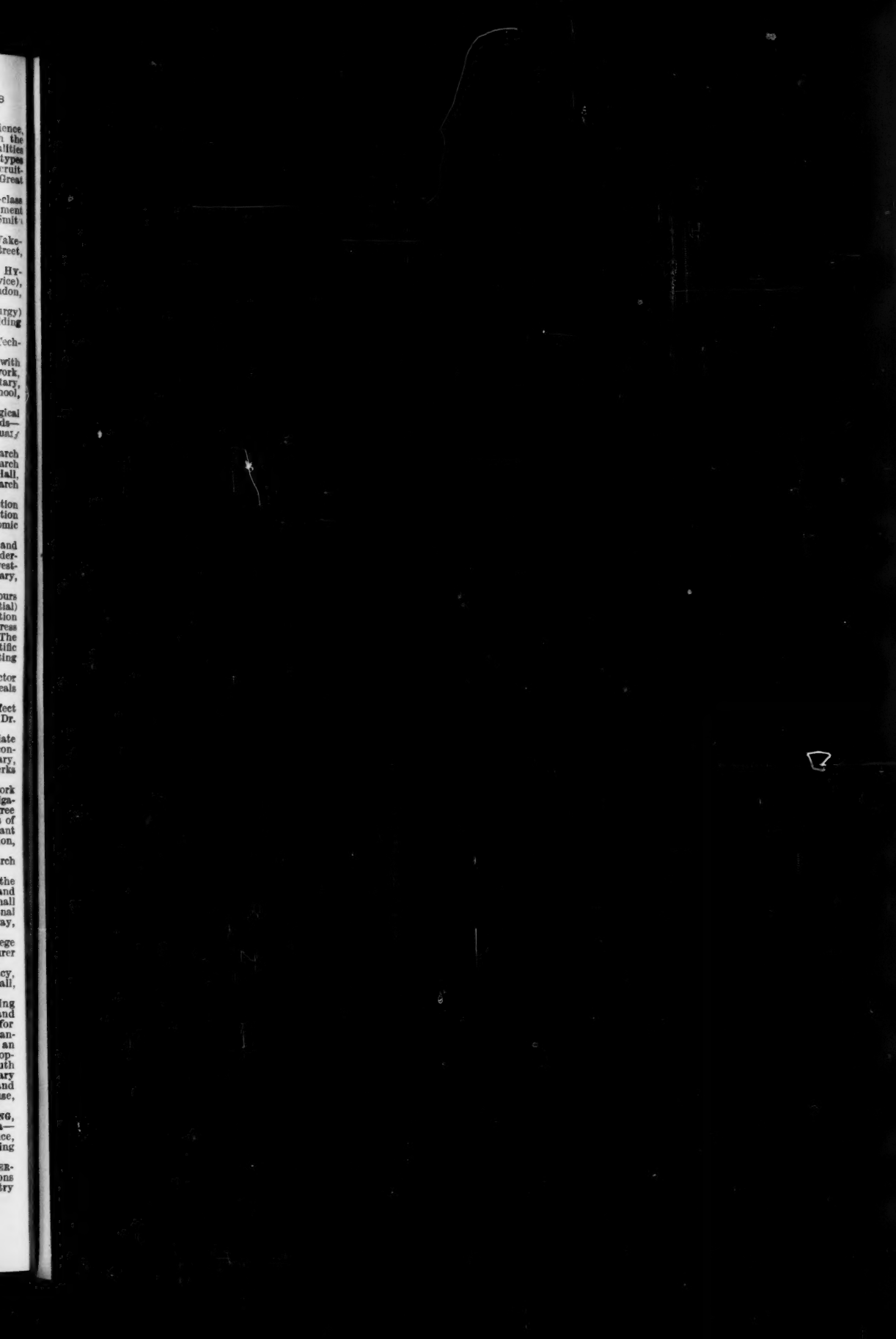
RESEARCH SUPERINTENDENT—The Secretary, Linoleum Research Council, Roxburghe House, 273 Regent Street, London, W.1.

SENIOR EXPERIMENTAL OFFICER or EXPERIMENTAL OFFICER at the Royal Aircraft Establishment, Farnborough, for the design and development of small clockwork mechanisms and associated small electro-mechanical devices—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting C.405/51A.

SENIOR LECTURER IN AIRCRAFT DESIGN—The Registrar, College of Aeronautics, Cranfield, Bletchley, Bucks, endorsed 'Senior Lecturer in Aircraft Design'.

SENIOR LECTURER IN PHYSIOLOGY in the Department of Pharmacy, Bradford Technical College—The Director of Education, Town Hall, Bradford.

SENIOR SCIENTIFIC OFFICER (Ref. E.503/51A) for engineering development and research covering a wide range of structures and mechanisms, a SENIOR EXPERIMENTAL OFFICER (Ref. E.504/51A) for work on the design of steel and alloy structures, including the mechanical testing of metals and some metallurgical examinations, and an EXPERIMENTAL OFFICER (Ref. E.505/51A) for engineering development and research, at a Ministry of Supply establishment in the South of England dealing with the design and development of military bridging and associated equipment—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No.

UNIVERSITY GRADUATES IN MATHEMATICS, PHYSICS, ENGINEERING, or GEOGRAPHY (including Geodesy) as SURVEYORS, Tanganyika—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting Ref. No. 27076/21/51.

UNIVERSITY GRADUATES IN PHYSICS, MATHEMATICS and ENGINEERING, for Permanent Commissions or for Short-Service Commissions in the Education Branch of the Royal Air Force—The Air Ministry (A.R.1), Kingsway, London, W.C.2.